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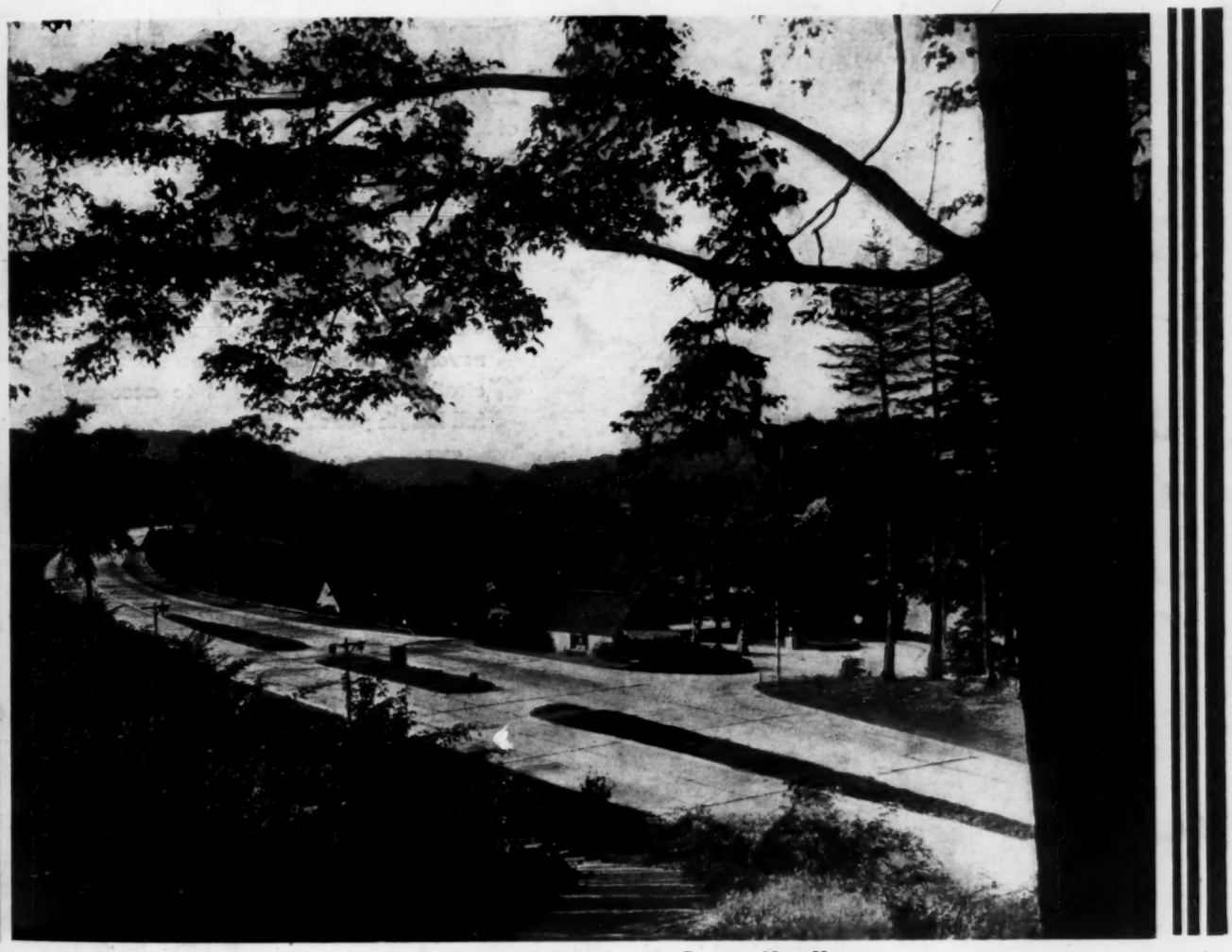
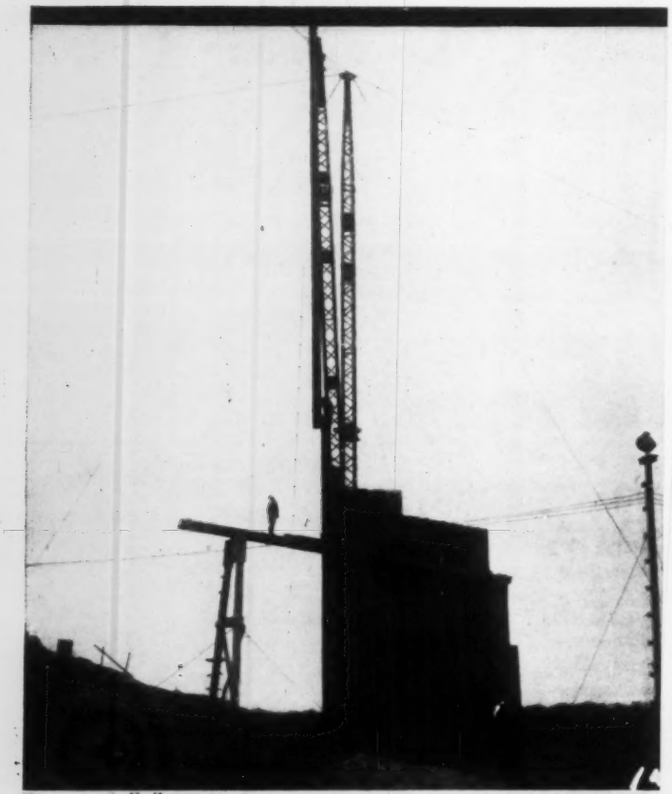


SAWMILL RIVER PARKWAY, WESTCHESTER COUNTY, NEW YORK

Volume 4 — Number 2

FEBRUARY 1934

Contractor reports phenomenal driving of Inland Sheet Piling



Construction views of La Fruta Dam for City of Corpus Christi, Texas, in which 1700 tons of Inland Section I-27 (formerly ID 16-25) were used. J. L. Simmons Company, contractors. R. J. Cummins & Henry E. Elrod, consulting engineers.

At top: A 79-foot pile suspended with 110-foot boom for interlocking with wall.

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Among Our Writers

E. W. LANE received his B.S. at Purdue and his C.E. at Cornell. He has been connected with a number of flood control projects, including those for the Miami River at Dayton, Ohio, and vicinity; for the Arkansas River at Pueblo, Colo.; for the Mississippi River from Cairo to the Gulf; and in China for the Huai and Yangtze rivers. He has also been engaged on studies for regulating the level of the Great Lakes, for the St. Lawrence Waterway, and for the Boulder Dam project.

HELGE FUGL-MEYER, a graduate of the Technical University of Copenhagen, Denmark, was engaged in the concrete department of Andersen, Meyer and Company, Shanghai, in 1919. In 1920 he became Engineering Assistant in the Whangpoo Conservancy Board, Shanghai, and in 1921 assistant to the "Shanghai Harbor Investigation," in which a number of the world's greatest experts had part. He served the Whangpoo Conservancy Board until 1929, for 3 years in charge of its construction department. In 1929 he became Chief Engineer of the Copenhagen Free Port Company and in 1932, manager of the same company.

HERBERT D. VOGEL, a 1924 graduate of the U. S. Military Academy at West Point, received his master's degree in civil engineering at the University of California in 1928, and his doctor of engineering degree the following year at the Technical University of Berlin. From 1929 to the present he has been at the U. S. Waterways Experiment Station in charge of design and construction and as its director.

HERBERT H. WHEATON, after receiving his B.S. in civil engineering from the University of Wisconsin, became instructor and Assistant Professor of Engineering at Fresno State College. For three years he was Engineer for the Fresno State College Association, and in 1929 received his M.S. in civil engineering at the University of California, where he did graduate research in hydraulics the following year. In 1932–1933 he was a Freeman Traveling Scholar of the Society. At present he is Associate Professor of Engineering and Mathematics at Fresno State College.

W. G. HOYT was engaged in the work of the Water Resources Branch of the U. S. Geological Survey from 1909 to 1920, and since with the Conservation Branch of the Geological Survey in connection with water utilization problems on the public domain. He has served on national and international committees in connection with water problems and more recently on advisory committees of the National Land-Use Planning Committee.

JAY DOWNER in 1902–1903 was Chief Engineer of the Cape Breton Railway Company, Nova Scotia. After two years as Superintendent of Construction for the Aluminum Company of America he served as engineer for Scarsdale, N.Y., in charge of design and construction of real estate developments and preliminary investigations for the Bronx River Parkway. From 1912 to 1925, he was Engineer and Secretary of the Bronx Parkway Commission. From 1933 to date, he has been Chief Engineer of the Westchester County Park Commission. Since 1931 he has also been County Engineer, County of Westchester.

RALPH W. STEWART'S early years were spent in railroad service and involved much field work in realigning main-line curves and introducing spirals at the ends and between branches of compound curves. Since 1909 he has been employed by the City of Los Angeles, where his work has been in bridge and miscellaneous structural design.

H. G. PAYROW, since his graduation from Tufts College, has been employed on various municipal projects. During the World War he was with the U. S. Public Health Service at Camp Merritt. Recently he designed a sewer system and treatment plant for Nazareth, Pa., installing the first revolving sewage distributor for a large trickling filter in the East. He is the author of various articles on sanitary engineering. Since 1916 he has been an instructor and then Assistant Professor of Civil Engineering at Lehigh University.

VOLUME 4 NUMBER 2

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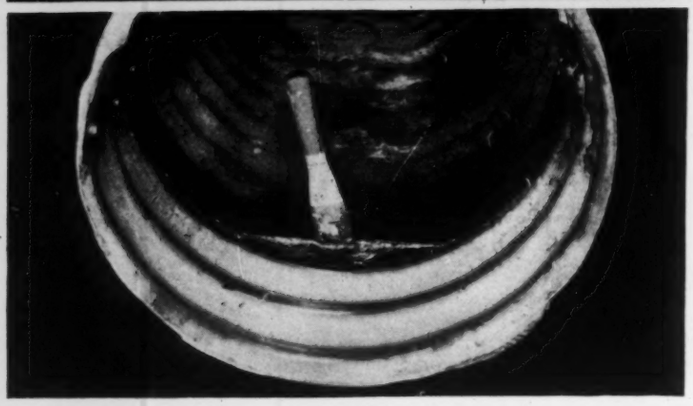

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VOLUME 4

NUMBER 2

History of Flood Control on the Mississippi

Essential Features of the Various Theories and Plans Promulgated to Date

By E. W. LANE
MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
HYDRAULIC ENGINEER, DENVER, COLO.

A RAPID and radical change in the program for the control of floods on the Mississippi River has taken place in the past few years. Adoption of spillways in the plan authorized in 1928 and experimentation with cut-offs and channel enlargement, which has been carried on more recently, have opened what may be considered a new chapter in the history of Mississippi flood control. The report of the board appointed to reconsider the Army Engineers' Plan of 1928 is ready for presentation at this session of Congress and will soon be the subject of considerable discussion. It is therefore appropriate that a historical summary of the various theories that have been held and the various plans prepared should be presented at this time. This article, which is an abstract of a longer paper available in the Society's files, is a concise record of facts formerly to be found only in obscure and widely scattered sources.

FLOOD control on the Mississippi River goes back to the time of the earliest settlement. The engineer who laid out New Orleans in 1717 provided for a levee along the river front, and by 1735 the levees extended for about forty miles. In 1844 they reached from about twenty miles below New Orleans to the mouth of the Arkansas River on the west side and to Baton Rouge on the east, and there were some isolated levees on the lower part of the Yazoo Basin. Great impetus to levee building was given by the Swamp Land Act of 1850, by which the Federal Government returned to each state all the unsold swamp and overflowed land within its borders, the proceeds from its sale to be used for reclamation.

From earliest times the question of how best to control floods on the Mississippi River has been the subject of violent controversy. Opposing schools of thought developed and influenced the course of future events. In order to understand the history of the progress of flood control it is necessary to digress somewhat to discuss some of the theories which have been held regarding the action of the river. One of these theories was that if levees were built the bottom of the river would fill up so that levee heights would have to be continually raised to keep ahead of the floods. This idea is still current among the uninformed, no doubt because of the gradually increasing flood heights caused by levees, but at the present time it is held by few if any engineers.

Another theory, which is generally ascribed to Guglielmini, a great Italian scholar of the seventeenth century, may be called the "confinement theory." It assumes that a river flowing in an alluvial bed carves out for itself a channel of capacity sufficient for its needs. According to this theory, if the flow of a river is reduced, the size of the channel decreases, and if the flow increases, the channel also increases. It assumes that normally there is an exact balance between scour and deposit and that any condition which causes an increase in velocity also causes an increase in scour and thus an enlargement of the channel. Conversely, a decrease in velocity causes a deposit of silt and thus a decrease in the size of the river bed. The proponents of this theory held that by preventing the escape of water to the swamps, levees on the Mississippi would increase the flow in the main channel and therefore the velocity. As a result scour would take place, rapidly enlarging the channel sufficiently to take care of the additional flow. They there-

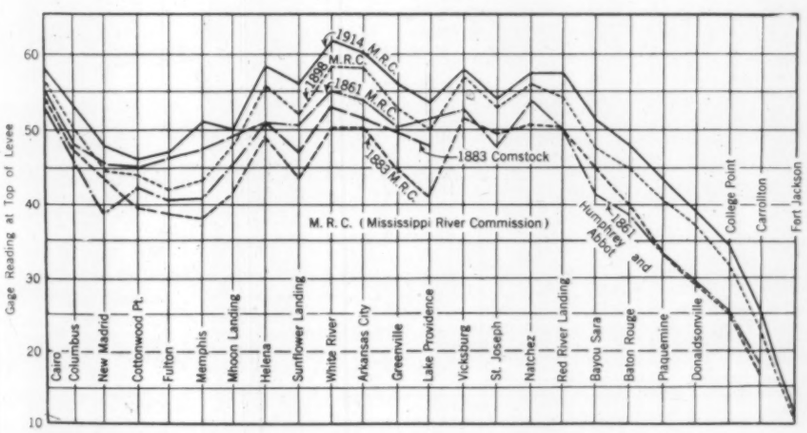


FIG. 1. COMPARISON OF LEVEE GRADES FOR THE LOWER MISSISSIPPI RIVER

fore advocated confinement of the entire flow of the river between levees, whence the name "confinement theory."

This theory was also used as an argument against outlets and spillways on the ground that to take water out of the river would decrease the velocity below the outlet, causing a deposition of silt and a decrease in discharge capacity, which would counteract the effect of the diversion. This theory was widely held, and until the 1927 flood was the basis of the flood control policy on the Mississippi. From the beginning this theory has been under attack, but it is still held by some engineers.

THE HUMPHREYS AND ABBOT REPORT

In 1851 started what proved to be one of the brightest chapters in the history of Mississippi flood control—the studies by Gen. A. A. Humphreys and Col. H. T. Abbot, leading to the publication of the classic *Report on the Physics and Hydraulics of the Mississippi River*. These studies were suspended in the fall of 1851, resumed again in the fall of 1857, and continued in 1858 and 1859. The report was submitted in 1861 and reprinted with slight additions in 1876. Very fortunately the period of the surveys covered the two large floods of 1851 and 1858, which fact permitted observations on high discharges and on breaches in the levees, or "crevasses" as they are called on the Mississippi. For years this report was an outstanding authority on the hydraulics of the river and is still frequently quoted. In the light of present knowledge it is of course somewhat out of date, and many of the minor conclusions are known to be incorrect, but considering that it was written nearly three quarters of a century ago, one marvels at its high quality.

In it Humphreys and Abbot discussed most of the methods of flood control which are given serious consideration today. Diversion of tributaries and cutoffs were declared impractical. Reservoirs were also considered not feasible. Whatever one may think of their practicability now, there is no doubt that for the conditions existing at that time this conclusion was correct. The report advocated a system of levees with the grades shown on Fig. 1. A spillway near Lake Providence was also recommended if the nature of the soil permitted. The contention that spillways would cause a filling up of the river bed below was denied. The remarkable character of the studies made by Humphreys and Abbot can hardly be overemphasized. The experience of the last seventy years has amply demonstrated the essential soundness of their conclusions, although it is true that the levee grades they proposed would have proved inadequate if adopted.

COMMISSION APPOINTED TO STUDY PROBLEM

About the time the report was submitted the Civil War broke out, so that nothing of importance was done until, by act of Congress in 1874, a commission was appointed "to investigate and report a permanent plan for the reclamation of the Alluvial Basin of the Mississippi River subject to inundation." The commission's report, contained in the *Report of the Chief of Engineers, U. S. Army*, 1875, Part I, page 536, followed very closely the recommendations of Humphreys and Abbot.

Most levee engineers did not accept the conclusions

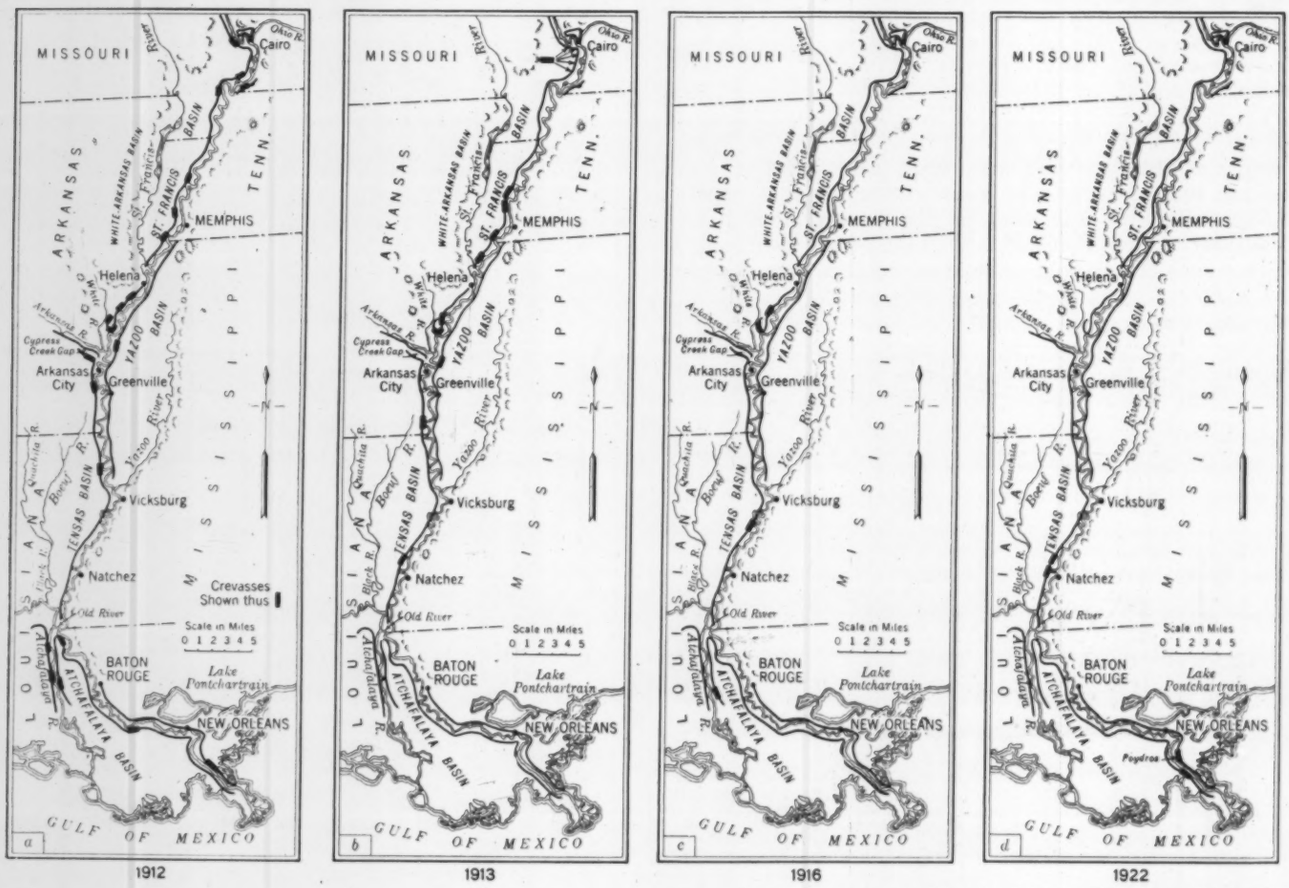


FIG. 2. LEVEE CREVASSES MADE BY MISSISSIPPI RIVER LEVEE

of Humphreys and Abbot or of the Commission of 1874 but continued to believe in the confinement theory, and as General Humphreys was then Chief of Engineers, Congress was persuaded in March 1881 to form the Mississippi River Commission. Its first report, *Report of the Chief of Engineers, U. S. Army*, 1881, Part III, page 2,720, was a complete reversal of the recommendations of Humphreys and Abbot and was based entirely on the confinement theory. It condemned the use of any form of outlet on the ground that this would cause a deterioration of the main channel below, which would neutralize the effect of the outlets and eventually produce a greater slope in the river below than formerly existed, and therefore greater flood heights above. Moreover it was declared that outlets would soon fill with silt and become useless. Cut-offs were also condemned. It recommended levees, not only as a means of flood control but also to improve the low-water channel of the river. Thus, from its first report, the Mississippi River Commission committed itself to the principle of "levees only" for flood control, a position which it consistently maintained until the flood of 1927.

PROVISO THAT FUNDS MUST BE USED ONLY FOR IMPROVING RIVER CHANNEL

Since most of the members of Congress did not believe in appropriating funds for the protection of private lands, a proviso was put in the law forming the Mississippi River Commission, as follows:

> No portion of the sum hereby appropriated shall be used in the repair or construction of levees for the purpose of preventing injury to lands by overflow, or for any other purpose whatever except as a means of deepening or improving the channel of said river.

Soon after the inauguration of the Commission an extensive program of discharge measurements and silt observations was undertaken. Fortunately for the completeness of these studies, 1882, 1883, and 1884 were all years of unusually high flood. Valuable records were obtained which otherwise would never have been available. The scope and thoroughness of the investigations is remarkable, and it is a matter of great misfortune that the results were buried in the annual reports of the Chief of Engineers.

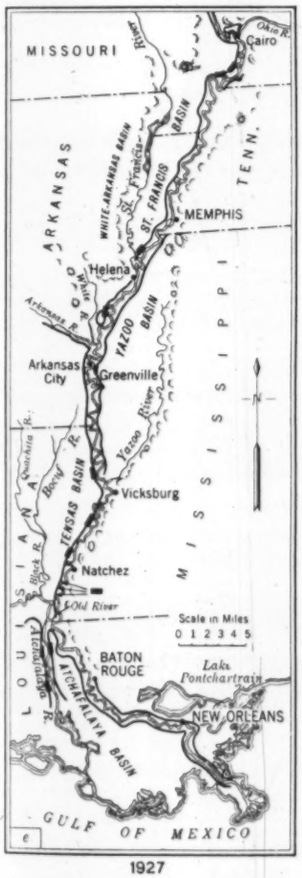
During the floods of 1882, 1883, and 1884 a stage was reached at Cairo greater than any until 1912 (Table I), practically thirty years later, when levee construction held the water to much higher stages. The 1883 and 1884 floods were not so great farther down the river, but the 1882 flood was one of the highest on record; many authorities believe it to be the highest prior to 1927. The stages which it caused in the lower river were soon exceeded, because of the construction of levees, but there is little doubt that this flood and those of 1912 and 1927 rank as the three largest floods on record on the Lower Mississippi River.

In 1883 the Commission established its first provisional levee grade at the height shown in Fig. 1. Along most of the river this grade was considerably lower than that recommended by Humphreys and Abbot. One member of the Commission, General Comstock, did not approve of the 1883 grade and recommended a higher one, also shown in Fig. 1.

LOW-WATER CHANNEL NOT IMPROVED BY LEVEES

The gradual extension of the levee system continued after the repairs of the 1884 flood damage were completed. As no material lowering of the river bed was shown by detailed cross-sectional measurements, it gradually became evident that levees were no aid in improving the low-water channel for navigation. In 1892 the law governing the expenditure of funds for levees was modified to read that the funds appropriated "shall be expended for the general improvement of the river, for the building of levees and for surveys . . . in such manner as in their opinion shall best improve navigation and promote the interest of commerce at all stages of the river."

This permitted the Commission to construct levees, on the ground that they were a benefit to navigation during high stages of the river. The necessity of justifying expenditures for levees on this ground was a severe handicap to the attainment of a rational point of view on flood control.



RECENT MAJOR FLOODS
System

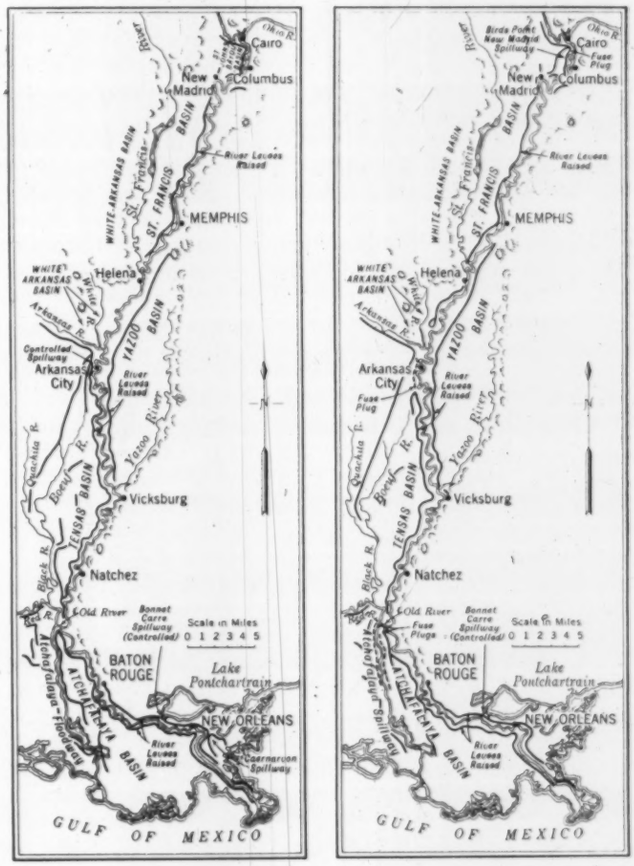


FIG. 3. PLANS PROPOSED AFTER 1927 FLOOD

As a result of the high water of 1897, it became evident that the provisional grade of 1883 was inadequate and although the levees had not been completed to that grade, a new and higher grade was established in 1898, as shown in Fig. 1. Floods of considerable magnitude, with increased gage heights, occurred in 1897 and 1903. The year 1912 brought one of the largest and most disastrous floods in the history of the valley. Many believe it was the largest prior to 1927. The stages at all gages except Vicksburg reached new high levels, as shown in Table I. Fourteen crevasses occurred, located as indicated by the heavy black sections on the levee lines in Fig. 2(*a*), and thousands of acres of cultivated land were overflowed.

TABLE I. MAXIMUM FLOOD HEIGHTS ON THE MISSISSIPPI RIVER

PLACE	ELEVATION OF ZERO ON GAGE	MILES FROM CAIRO	MAXIMUM STAGES REACHED						MAXIMUM STAGE TO DATE	DATE OF MAXIMUM STAGE
			1912	1913	1916	1920	1922	1927		
Cairo	270.41	0	53.9	54.7	53.2	51.4	53.6	56.3	56.3	4/18–20/27
Columbus	266.46	21.6	49.0	49.3	48.6	47.0	49.0	51.0	51.0	4/16/27
New Madrid	255.96	71.0	44.1	44.6	41.9	40.2	41.8	43.5	44.6	4/9/13
Cottonwood Point	230.50	124.5	42.0	42.2	39.5	37.6	38.5	40.1	42.3	4/11–12/13
Fulton	208.74	175.4	43.3	44.1	40.2	37.2	39.1	42.2	44.1	4/9/13
Memphis	184.21	227.0	45.2	46.6	43.4	40.3	42.5	45.8	46.6	4/9/13
Mhoon Landing	161.35	273.2	44.9	45.3	44.8	42.9	45.1	47.0	47.0	4/25–26/27
Helena	141.81	307.1	54.3	55.2	53.4	50.1	53.1	56.8	56.8	4/26–27/27
Sunflower Landing	−127.25	353.7	50.8	51.3	51.6	48.2	51.0	53.2	53.2	4/22/27
White Flower	108.86	391.7	56.4	55.4	56.5	53.1	56.8	60.0	60.0	4/21/27
Arkansas City	96.75	436.7	55.3	55.2	56.4	54.0	58.0	60.5	60.5	4/21/27
Greenville	88.53	480.2	50.8	50.4	50.8	47.0	52.0	54.6	54.6	4/21/27
Lake Providence	69.77	543.0	48.2	48.0	48.8	45.4	49.5	50.4	50.4	4/21/27
Vicksburg	46.16	601.8	51.6	52.2	53.8	50.9	54.8	58.5	58.5	5/4/27
St. Joseph	33.15	662.4	48.6	49.5	50.8	48.4	52.2	54.6	54.6	5/3–4/27
Natchez	17.09	705.7	51.4	52.6	53.5	51.5	55.3	56.6	56.6	5/3–4/27
Red River Landing	3.57	772.6	53.2	50.6	52.4	50.3	55.3	57.5	57.5	5/14–17/27
Bayou Sara*	3.83	806.9	47.4	44.5	46.1	44.7	49.4	51.7	51.7	5/15/27
Baton Rouge	−0.42	841.0	43.8	41.3	42.6	41.5	45.7	47.8	47.8	5/15/27
Plaquemine†	0.28	861.0	39.4	36.8	38.8	37.1	41.1	43.0	43.0	5/15/27
Donaldsonville‡	−1.25	892.8	35.1	32.7	34.0	32.6	35.9	37.2	37.2	5/15/27
College Point	0.29	911.3	30.2	28.2	29.4	28.0	30.9	32.0	32.0	5/15/27
Carrollton	−0.13	964.5	21.0	19.3	20.0	19.2	21.3	21.3	21.3	4/25/22
Fort Jackson	−1.68	1,046.8	8.3	8.3	8.8	8.5	9.6	9.2	9.6	4/26/22

* Zero reading at Bayou Sara in 1912, 1913, and 1916 was 0.04 above 1922 and 1927.
† Zero reading at Plaquemine in 1912, 1913, and 1916 was 0.10 below 1922 and 1927.
‡ Zero reading at Donaldsonville in 1912, 1913, and 1916 was 0.24 above 1922 and 1927.

In the following year, 1913, also a flood year, still higher stages were reached as far south as the mouth of the White River. At a number of points these are still the highest stages on record, being higher than those reached in 1927. Again many crevasses occurred, Fig. 2(*b*), and millions of dollars of damage was done. Since these floods demonstrated the inadequacy of the provisional grade of 1898, a third grade was established, known as the provisional grade of 1914. This was supposed to be 3 ft above the level that would have been attained by the 1912 flood had it been confined.

Work on the new 1914 grade was started immediately, and considerable progress was made before the next large flood came in 1916. This flood was not especially severe above the mouth of the Arkansas River, but there was an unusually high stage in that stream and record stages were reached between its mouth and Red River Landing. The 1916 flood brought to the front the problem of the Cypress Creek Gap. Cypress Creek is a small stream which entered the Mississippi from the west, about 22 miles by river below the mouth of the Arkansas River, where a gap was left in the levees to permit the flow of Cypress Creek to reach the Mississippi, as shown in the first three parts of Fig. 2. This gap could not be closed until an outlet was provided for the waters of Cypress Creek. As the flood levels increased, more and more water from the river escaped through this gap, reaching 335,000 cu ft per sec in 1916. A plan was finally worked out for diverting the Cypress Creek waters through a large excavated channel southward to Bayou Macon. When this channel was completed the gap was closed.

In 1917 Congress passed a new act, which fortunately removed the necessity for further subterfuge regarding expenditures for levees, and put the work on a straightforward flood-control basis. It provided that:

> No money appropriated under the authority of this act shall be expended in the construction or repair of any levee unless and until assurances have been given satisfactory to the Commission that the local interests protected thereby will contribute for such construction and repair a sum which the Commission shall determine to be just and equitable, but shall not be less than one half of such sum as may have been allotted by the Commission for such work.

The next destructive flood occurred in 1922. Like that of 1916 it was not so severe in the upper part of the river, but the peak flow of the Arkansas River arrived just between two high crests in the Mississippi. Since the Cypress Creek Gap was closed, the result was the highest stages up to that time at all gages below the entrance of the Arkansas River (Table I). The crevasses caused in the main river levees are shown in Fig. 2(*d*). The safety of New Orleans was seriously threatened, but a crevass occurred at Poydras, just below, and lowered the stage at the city.

A profound impression was made on the citizens of New Orleans by the Poydras crevass. They laid plans for a controlled spillway below the city, but permission for its construction was not granted. However, another plan, known as the Point à la Hache Relief Outlet was put into effect just before the 1927 flood. This consisted of removing the levees from the east bank of the river for a distance of 9 miles, beginning 50 miles below New Orleans. The advocates of spillways in the vicinity of New Orleans also appealed to Congress and secured a law appointing what was known as the Mississippi Spillway Board, to investigate the feasibility of spillways for flood control below the point where the channel of the Old River leaves the Mississippi.

MANY CREVASSES OCCUR IN LEVEES DURING WORST FLOOD IN HISTORY OF MISSISSIPPI

Unquestionably the largest flood in the known history of the Mississippi, that of 1927, was caused by heavy rainfall centering over the Lower Mississippi Valley following a long period of wet weather and high water. By the first of March 1927, high stages existed throughout the Lower Mississippi, and especially high ones near the mouth. The months of March and April brought extreme rainfall, centering almost directly over the lower river, the high rainfall areas conforming in a remarkable manner with the limits of the drainage basin of the river. The result was large floods in all the principal tributaries. Moreover, the incidence of the individual heavy rains was such as to bring the peaks of flow on the various tributaries into nearly perfect synchronization, resulting in a great flood above the mouth of the Arkansas River and unprecedented flows below. The rainfall during March and April reached the remarkable total of 28 in. in the vicinity of Memphis, while 10 in. or more fell in most of Indiana, Illinois,

Missouri, Arkansas, Kentucky, Tennessee, Mississippi, and Louisiana.

The levee system proved inadequate for this great flow. Eleven crevasses occurred in the main levees, Fig. 2(*e*), and numerous others in the levees on tributary rivers. The greatest of these, in fact probably the greatest in the history of the river, was that at Mounds Landing on April 21, which flooded the highly developed Yazoo Basin, including the city of Greenville, Miss. The flood waters from all these crevasses spread over 28,000 sq miles, rendered 700,000 people temporarily homeless, and caused the loss of over 200 lives. That the suffering and loss of life were not greater was due to the efficient organization of the rescue work. The direct and indirect monetary loss reached approximately $300,000,000, making it one of the largest disasters in American history.

MORE ADEQUATE PROTECTION DEMANDED AS A RESULT OF 1927 FLOOD

Demands for more adequate flood protection were the immediate consequence of this great flood, which was followed by a series of engineering reports covering various phases of the problem. The first of these was that of the Mississippi Spillway Board, whose studies were under way when the flood occurred. It prepared a comprehensive project for protection below the Old River, as shown in Fig. 3.

Soon after the flood, a board was appointed to consider the possibilities of spillways for the entire Lower Mississippi. This board, known as the Diversion Board, adopted the plan proposed by the Spillway Board for that part of the river below the Old River. They investigated a floodway extending from the Mississippi at Cypress Creek via Bayou Boeuf to the Red River and recommended detailed surveys and estimates for this floodway, which was to have a capacity of 600,000 or 750,000 cu ft per sec. Above the Arkansas River the Diversion Board reported that spillways were impractical, since they would cost more than the equivalent protection by levees only. A Reservoir Board was also to investigate the feasibility of reservoirs as a means of flood control. It reported that this method was not economically justified because equivalent protection could be secured at a lower cost by other means.

A report on flood control plans for the entire Middle and Lower Mississippi was made by the Mississippi River Commission. It discussed a comprehensive plan for protection against the largest flood which reasonably might ever be expected to occur, recommended further studies, and advised the construction of part of the comprehensive plan. The major features of its plan were the same as those promulgated by the Diversion Board but differed somewhat in levee heights and capacities (Fig. 3).

JADWIN PLAN PREPARED

A plan for the protection of the entire valley was also prepared by the Chief of Engineers, U. S. Army, at an estimated cost of $296,400,000, which did not include payment for most of the right of way. This plan, known as the Army Engineers' or Jadwin Plan, recommended a floodway in the vicinity of Cairo to protect that city. From the end of this floodway to the mouth of the Arkansas River the levees were to be raised to a height sufficient to carry, with one foot of freeboard, a flood equivalent to a stage of 60 ft at Cairo. The levees between the mouths of the Arkansas and Old rivers were to be raised 3 ft. Starting about at Cypress Creek, a floodway of 900,000 cu ft per sec capacity was proposed, leading to the lower end of the Tensas Basin The upper end of this floodway was to be closed off by a levee known as a "fuse plug," having its top 3 ft lower than that of the main river levees. This "fuse plug" would be breached so as to bring the spillway into action before the main levees were overtopped. Below the Old River this plan provided a floodway, also closed by a "fuse plug," down both sides of the Atchafalaya River, with a combined capacity, including the river flow, of 1,500,000 cu ft per sec. The Mississippi was to carry the same amount to Bonnet Carré, just above New Orleans, where 250,000 cu ft per sec would be diverted through a spillway to Lake Ponchartrain and the remainder would pass down the river to the Gulf of Mexico.

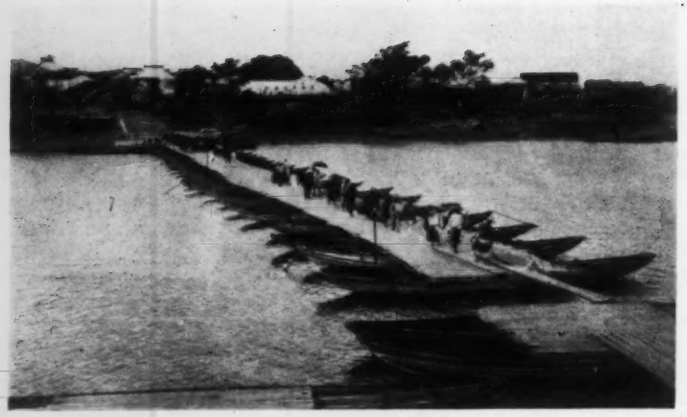
Hearings before congressional committees extended over several months in 1927 and 1928. The principal points of controversy were the plan to be adopted, the part of the cost to be assumed by the Federal Government, and the compensation to be paid to land owners in the proposed floodways. A number of plans for flood control were presented, but only the plan of the Mississippi River Commission and that of the Army Engineers were seriously considered. The major differences in the plans concerned the use of controlled versus "fuse plug" spillways and the advisability of further studies, particularly of reservoirs. These hearings led to the Flood Control Act of 1928 and adoption of the Army Engineers' plan.

CUT-OFFS AND CHANNEL ENLARGEMENT

Adoption of the Army Engineers' plan led to a great deal of controversy and litigation. However, a new Chief of Engineers, Lytle Brown, M. Am. Soc. C.E., appointed a board of engineers to make a complete reexamination of the problem. The report of this board will be presented to the present session of Congress. Unless major weaknesses in the plan develop, the recommendations in the report, with such modifications as Congress may make, will probably constitute substantially the final plan for flood control on the river and will provide for the ultimate if not for the immediate protection of all land for which protection is economically feasible, against the greatest flood reasonably to be expected.

In 1932 Gen. H. B. Ferguson was appointed Chairman of the Mississippi River Commission. Under the direction of Generals Brown and Ferguson a new chapter in the history of Mississippi flood control was entered. Exhaustive study and research in many phases of the flood control problem were inaugurated. These extended even to an investigation of methods that were considered by many to be impractical. By means of models in the U. S. Waterways Experiment Station at Vicksburg, cut-offs were studied in detail. The results completely reversed the policy of preventing cut-offs and led to the actual construction of a number of them. The policy of preventing the enlargement of the Atchafalaya River has been changed to one of making this stream carry a larger flow. Fundamental researches on the transportation of solids in rivers and on other problems are being carried forward. Extensive study for the development of new methods of revetment is under way.

It is yet too early to say what the outcome of these revolutionary changes will be. There can be little doubt, however, that the present open-minded attitude of investigation and experiment is a great advance over the extremely conservative policy which has characterized much of the flood control work on the Mississippi River in the past.



A Pontoon Bridge in China
The Loose Planks at the Two Openings Are Removed by the Floating Traffic and Replaced by the Pedestrians

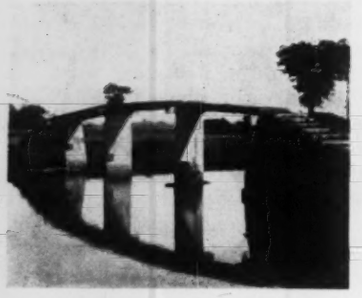
Bridge-Building, an

Many Strange and Picturesque Types Have

By Helge Fugl-Meyer,

Director of the Free Port

PRACTICALLY all traffic in China is water borne. Roads are narrow and winding and vehicles are few. Yet there is a never-ceasing queue for pedestrians, beasts of burden, and sedan chairs crossing the countless rapid creeks and rivers. For centuries this need has been met by many types of bridges, numbering into the millions. Since they must be high above the water to clear the floating traffic, their approaches are steep, often in the form of steps, and are difficult if not impossible to adapt to modern wheeled



Stone Trestle Bridge Across a Small Creek

WITHOUT its thousand graceful and venerable bridges, China would not look Chinese. The Chinese character *chiao*, denoting a bridge, contains in its components the idea of a lofty wooden construction. This character was formed about 1003 B.C., indicating in agreement with Chinese legendary history that fairly large wooden bridges were built at a very early date. From the Confucian annals it is known that pontoon bridges have been in regular use since 600 B.C.

At the same early date a number of communities with a relatively high civilization existed in the parts of Central Asia which now form the western borders of Chinese territory. The inhabitants were skilled sluice- and canal-builders and since fierce and wide mountain streams made all communication difficult in those parts of the world, nature made them bridge builders long before the written records of their kingdoms began. In these regions a number of interesting wooden cantilever bridges and suspension structures are still to be found.

At a later date the cantilever bridge developed into a structure which combined stone masonry and wood, and the bamboo ropes in the suspension bridges were replaced by heavy chains. Judging from local inscriptions, this last development took place as late as the fifteenth century.

It appears that the beautiful and typically Chinese arch bridge was introduced into the country during the later Han dynasty (25 to 221 A.D.). The arch is one of the great inventions of the ancient Mesopotamian peoples. The Chinese learned the art at about the same time as the Romans, both from their contact with Parthia, which in those days was the main inheritor of the glorious civilizations of Mesopotamia.

A Chinese military expedition against the Huns penetrated as far as the Black Sea and sent a mission to Parthia in order to report on the buildings, art, and culture of the country. Shortly afterwards the first arch constructions and cupola graves seem to have appeared in China. Through the introduction of Buddhism at the same time another encouragement was given to bridge building. One of the meritorious acts of Mahayana Buddhism was that of building a public bridge. This idea came into Buddhism from the ancient Persian religion. There is thus a double indication of a Near-Eastern origin for the Chinese arch.

A Stone Trestle Bridge in Soochow

Most of the bridges in China are built only to accommodate pedestrians, sedan chairs, and pack animals. The steep abutments and steps make it difficult to adapt them to modern wheeled traffic. If an exhaustive description of Chinese bridges were to be presented the country would have to be subdivided and each part taken up separately. Here, however, the subject must be treated as a whole. Therefore the bridges will be described according to their types under the following headings: simple trestle bridges, arch bridges, cantilever bridges, and suspension spans.

Of the multitude of bridge types found in China the

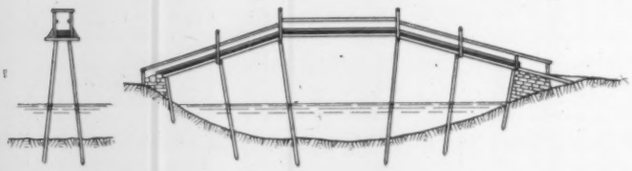


Fig. 1. Simple Wooden Trestle near Chingpu, Kiangsu
Central Span About 30 Ft Long; Clearance About 17 Ft

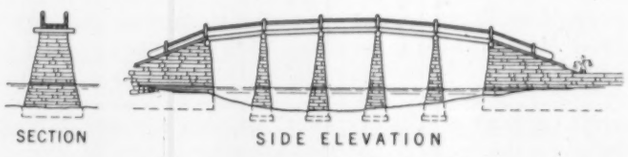


Fig. 3. Stone Trestle Bridge at Pinghu
Built in the Sung Dynasty

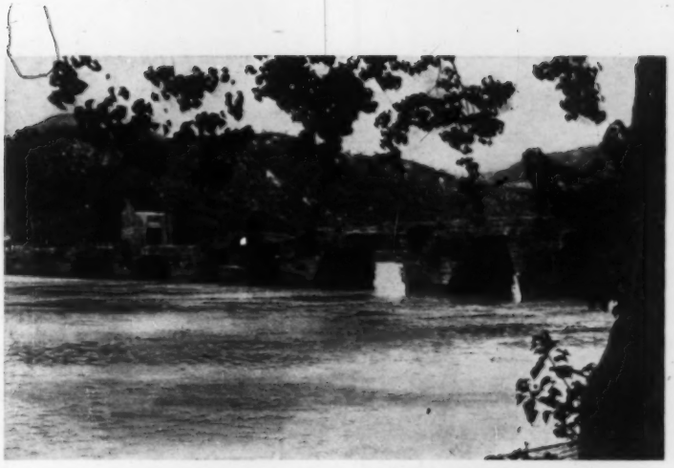
Art of Ancient China

Been Developed in the Course of Centuries

ASSOC. M. AM. SOC. C.E.

OF COPENHAGEN, DENMARK

traffic. Among the common types are art bridges, a picturesque feature of the Chinese landscape, and a flexible construction adopted for use on mud and sand foundations. Unique among the many bridge types is the stone trestle, often built with tremendously heavy stone beams up to 70 ft in length. In the suspension type, bamboo ropes, which must be replaced frequently, and hand-forged iron chains are generally found. From a personal study, Mr. Fugl-Meyer here presents a vivid picture of bridge construction in old China.



FAMOUS POH LAM BRIDGE OVER THE DRAGON RIVER Near Amoy; Some of Its Stone Beams Are 70 Ft Long and Weigh 200 Tons Each

RUINS OF AN ARCH BRIDGE NEAR CHUNG KING, SZECHWAN

ordinary wooden trestle is the earliest. The oldest stone carvings from the Han dynasty show that the ancient wooden bridges had the same shape as those found today. In most parts of the country the climate is moist and warm, causing timber to decay rapidly.

ANCIENT ARCH OVER THE YANGTZE AT WANHSIEN, SZECHWAN

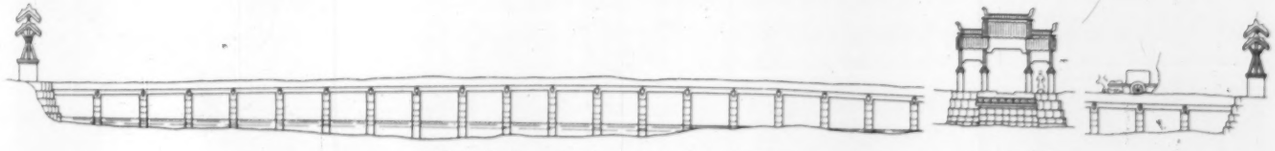
In this type of construction, illustrated in Fig. 1, the supports consist of slender round piles driven 5 or 6 ft into the soft muddy creek bottoms by means of a stone rammer manipulated by hand. The ramming is usually done by six or eight coolies standing on a platform rigged up on the pile itself, who thus add their own weight to the downward forces. Slender round stems placed side by side from support to support form the deck. Across the top of the beams a layer of smaller branches is fastened and covered with mud. A bridge of this kind will last only from two to six years in East China.

As the next step in bridge engineering, this type was copied in stone. Such a bridge, from the oldest part of civilized China, near Sian, is shown in Fig. 2. The supporting piers are of cylindrical stones imitating wooden piles. In the most common truss construction for bridges of this type, in the Yangtze River delta, the stones are mortised into each other without the use of mortar, as in a wooden structure. The abutment walls are thin granite slabs from which binder stones extend into the interior loose fill to stabilize the walls. There are thousands of these bridges.

The manufacture of the long, flat stone elements is an industry in itself. Throughout the river delta wherever a hill of suitable material lifts itself above the muddy flat, the clanging of stone hammers is heard cutting out stones for such bridges. A number of standard sizes are manufactured and shipped by river craft to towns and villages where local stone-cutters keep their stock. The width of the stones is ordinarily about 14 in. but for extraordinarily long spans it is often considerably greater. An unimportant country bridge is only one stone wide, but bridges of several spans over important creeks are from three to five stones wide and generally have a low parapet wall at the sides.

The foundations for piers and abutments consist of specially wide and heavy stones. If the creek bottom is very soft, a number of slender piles are driven under the whole foundation. The foundations are always built in a dry pit formed by two arched cofferdams.

Another type of bridge, from the Yangtze delta at Pinghu, near the old capital of the Sung dynasty, is shown in Fig. 3. It appears from all evidence that the pier type here shown was in special favor during that dynasty. Several of these bridges date back to about 1100 A.D. During the Sung dynasty, when the old northern territories of China had fallen into the hands of the Tartars, and the Emperor had built his new capital south of the Yangtze River, great activity was started to develop the southern provinces. The result was that stone trestle bridges reached their highest form in every sense of the word, so much so that it has not even been possible to reconstruct them as they fell into decay. At Tsien-chowfu, a wide and navigable stream is spanned by a bridge 3,780 ft long, 16 ft wide, consisting of 47 spans, and



SIDE ELEVATION SECTION

FIG. 2. OLD STONE TRESTLE BRIDGE NEAR SIAN HAS ROADWAY BEAMS COVERED WITH EARTH

AN ARCH OVER A CANAL IN SOOCHOW

Its Shape Has Changed Because of the Tipping of the Abutments, Yet Because of the Method of Construction the Arch Has Adapted Itself to the New Conditions

having massive approach fills 800 ft long. At Changchowfu two bridges 2,000 ft long were built with a curve upstream against the current of the Shao River. The most impressive of these giant stone trestle bridges is the Poh Lam Bridge 20 miles up the Dragon River from Amoy. It is only 1,100 ft long but its longest span is 70 ft in length. The deck is 14 to 16 ft wide, and each of the main beams weighs about 200 tons. It remains a mystery how the builders were able to cut, manipulate, and place these giant stone beams with their primitive methods a thousand years ago. The bending resistance of the stone has been taxed to its utmost in this bridge, and several of the main beams have collapsed during the passing of the years. Later generations have been unable to replace them but have had to build smaller piers between the original ones to reduce the span length.

The old Chinese builder appears as a rule to have made the depth of the stone beams one-fifteenth of the span. This places the longer spans at a disadvantage.

For a number of bridges the maximum tension is about 900 lb per sq in. In the Poh Lam Bridge the tension bending stress from dead load alone is 820 lb per sq in. This is about four times that given in textbooks as the ultimate strength for stone. I purchased 12 stone slabs from a Chinese stoneyard and tested their bending resistance by supporting them at both ends on steel wedges and loading them in the middle through another steel wedge. The spans varied in length between 5.5 and 10.3 ft. The maximum tensile stress in the section where the rupture took place varied between 437 and 970 lb per sq in. The average strength of a selected even gray granite was as high as 916 lb per sq in. (varying between 848 and 970 lb per sq in.). These tests proved that through experience Chinese bridge engineers had learned to utilize the full strength of the material at hand. Unforeseen overloading always proves disastrous to a Chinese stone trestle bridge.

From an engineering point of view the arch type is by far the most interesting Chinese bridge structure. The oldest arches are found in northern and western China. A good example of the capability of the ancient builders is given in the illustration of the ancient arch over the Yangtze River at Wanhsien. Such structures are generally made of finely cut stones, without mortar. The arch itself (which is never skewed) is a shell of stones on the sides of which two parapet walls are built. Between these walls a loose fill of mud and stone chips is placed, and covered on the sides by a flight of steps and on top by stone slabs, often beautifully ornamented.

In North and West China the foundations for a bridge were generally rock or very firm strata, and there was plenty of building material at hand. The problem was easy to solve and the Chinese, with their genius for economy and adaptability, had no reason to reshape the designs inherited from other parts of the world. But when the arch construction was attempted in the plastic mud of the Yangtze delta the problem was quite different. An arch had to be invented which could stand uneven sinking of the abutments.

The solution of this problem is the most interesting of Chinese engineering feats. In Fig. 4 an arch bridge from the Yangtze delta, one of uncounted thousands, is illustrated. Under the foundation a number of piles were driven, and above these heavy stones were placed so that they interlocked in several layers. This stone foundation was carried a foot or more above high-water level. Between these foundations the main arch was built as a thin shell. It consists of long, narrow, curved stones placed side by side and parallel to the direction of the pressure and intersected by straight transverse stones

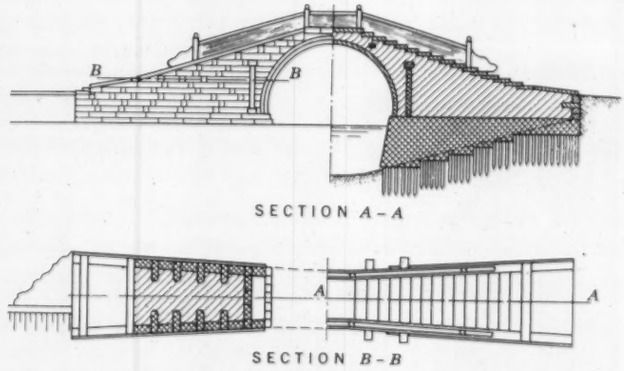


FIG. 4. AN ARCH ON A MUD FOUNDATION AT SOOCHOW, KIANGSU
Typical of Construction in the Yangtze River Delta

into which the first-mentioned stones were mortised. These stones are parallel to the axis of the arch and are as long as the bridge is wide. If one of these curved stones falls out it can be replaced without threatening the safety of the whole structure.

Parapet walls of granite, seldom laid in mortar, with a certain number of dovetailed stones between for the sake of connection, are erected on the granite foundation, and a fill of clay and stone chips is placed between the parapet wall and the arch. A stone wall is placed just behind the arch. It consists of long vertical stones mortised into the massive granite blocks below and connected

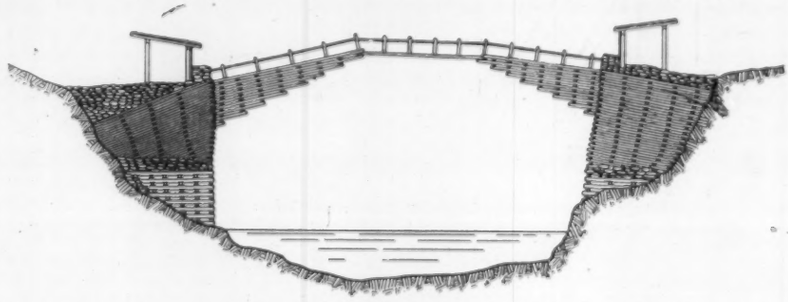


FIG. 5. WOODEN CANTILEVER BRIDGE, KINGDOM OF MULI

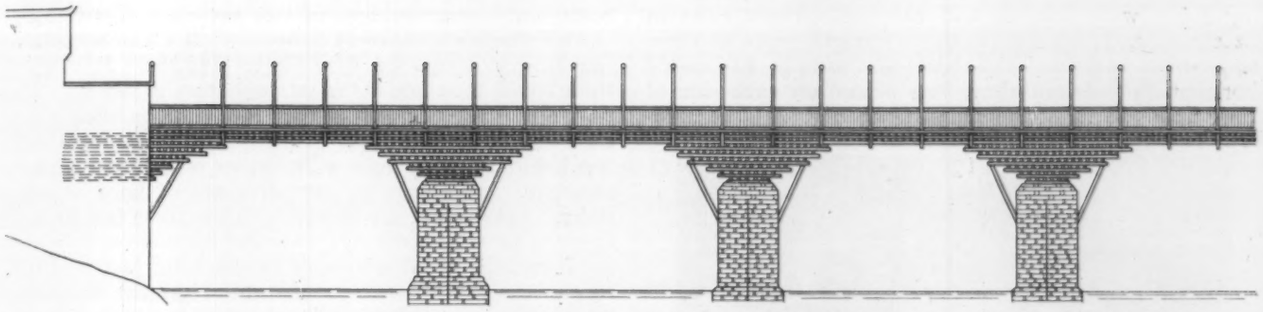


FIG. 7. A CONTINUOUS CANTILEVER BRIDGE IN HUNAN PROVINCE
Heavy Stone Piers Support a Wooden Superstructure

together at their tops by a long horizontal capstone which extends out through the parapet walls on both sides. This "resistance wall" is an essential part of the structure, as the arch in itself is a loose chain of stones, which can shape and reshape itself with the sinking and rising of the foundations but cannot resist any bending moment. The bending moments are transferred through the fill behind the arch to the two shear walls at each end of the arch. The arches are "over-curved," that is, their centers are above the supports, so that the shear walls are loaded slightly from the start, a condition which eliminates the danger that the arch will move away from the "resistance wall."

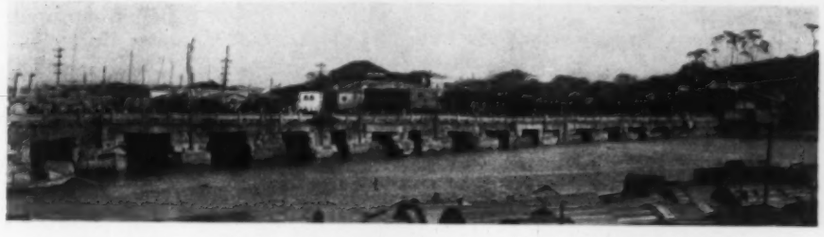
The whole system forms a wonderfully plastic unit in spite of its hard stone elements. Several old bridges on bad foundations have very odd shapes, but the stone chain arch and the resistance wall have been able to meet the changed conditions, so that the structures in their altered shape give perfect satisfaction to traffic. The photograph of the arch over a canal in Soochow gives an example of this flexibility.

The main arch of the ordinary bridge is daringly thin. Although I have measured hundreds of such arches, it has not been possible to determine any rule regarding their dimensions. In a bridge with different sized spans, such as the five-arched bridge near Chingpu, Kiangsu, the arch shells are thinner in the smaller spans. In many small structures the thickness is about one-thirtieth of the span, but in some of the larger bridges it may be as thin as one-sixtieth of the span.

WOODEN CANTILEVER BRIDGES IN FORESTED REGIONS

In the western and southwestern forested parts of China, stone-slab bridges are seldom found. Wooden or arch structures span the smaller streams, and a very interesting type of cantilever construction is generally used for longer spans, up to about 130 ft. Over still wider streams, suspension bridges are constructed.

Typical cantilever types are illustrated in Figs. 5 and 6. That in Fig. 5, from the small Tibetan-Chinese kingdom of Muli, has two heavy stone-filled wooden caissons, which lend stability to the two cantilever ends. The middle part or suspended span can be removed when the king of Muli finds it necessary to block this entrance to his realm. In Fig. 6 is a bridge from Yunnan. Planks have been placed on both sides to protect the beams against moisture. The cantilever beams are wedged into holes in the masonry of the piers and can be drawn out one by one and replaced when decayed. The middle part of the span consists of a single layer of tree trunks, five side by side, kept together by cross bars. A changeable plank covering takes the wear from traffic. This kind of bridge is sometimes constructed in two spans, with a heavy middle pier from which cantilever beams extend on both sides.



PART OF THE BRIDGE OF TEN THOUSAND AGES, IN FOOCHOW
A Stone Structure 1,270 Ft Long, 14½ Ft Wide, on 35 Piers

A bridge from Hunan Province is illustrated in Fig. 7. The heavy boat-shaped piers are designed to resist turbulent currents and the flooding debris. The wooden continuous cantilever construction is accomplished by a pile of slender trunks kept in place by thin, hard wooden pegs driven through holes wherever two stems cross. Supports for bamboo matting have been erected along both railings. The two last types of bridges are always a gathering place for the inhabitants of the neighboring town or village and are therefore generally roofed.

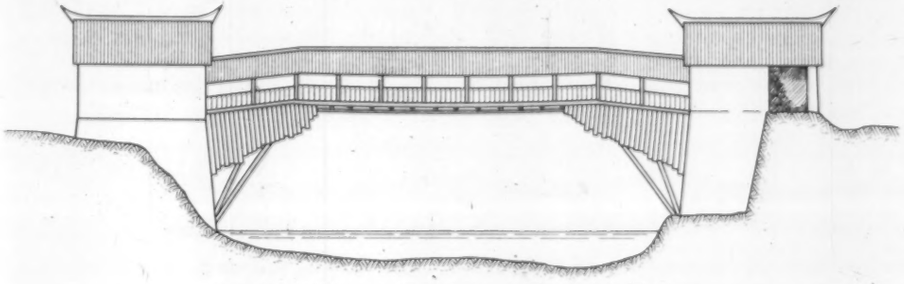


FIG. 6. A WOODEN CANTILEVER BRIDGE IN YUNNAN

The Chinese make very strong and durable plaited bamboo rope by means of which they tow their boats and barges along tow tracks against the current of navigable streams. At a very early date such ropes must have been used as a means of cross-

ing fairly wide streams and canyons. There exist in Szechwan and Yunnan provinces various types of these single-rope bridges. The best are usually suspended horizontally between shear legs placed on each side of the stream to be spanned. A basket which accommodates two persons is attached to a ring around the rope and is pulled across by means of a lighter rope. A simpler type consists of a rope supported high on shear legs on the one side and fixed to the rock several yards lower down on the other. Persons wishing to cross must either tie themselves to a ring that is fastened loosely around the high end of the rope, or to a curved yoke placed over the rope. When they let go their hold on the pole they rush over to the other side. There a flight of steps in the rock brings them up to the mountain track again. A similar rope sloping from the other bank serves the traffic in the opposite direction. In some places two ropes parallel to each other are suspended over the stream, one five or six feet above the other. Persons walking on the lower rope keep their balance by holding on to the upper rope. However uncomfortable such a crossing may be, it is the first indication of a real suspension bridge.

A BAMBOO ROPE SUSPENSION BRIDGE
This Construction Is Used for Spans Up to 250 Ft Long. From a Photograph by Robert Fitch

Most Chinese suspension bridges consist of one span. On each side of the gorge a substantial bridge house is built, in which there are two rows of columns. One bridge rope is fastened to each column, which can be turned as a capstan by the insertion of a bar into a hole made for the purpose, thus tightening the corresponding rope in the bridge. An illustration shows the stone weight in the upper part of the house, which prevents the columns from lifting themselves out of their sockets. Some single-span bridges of this type are 250 ft long.

At Kwanhsien the most famous of all Chinese suspension bridges spans the Min River (Fig. 8). It is more than 700 ft long and its maximum span is 200 ft. The bridge is 9 ft wide and is carried by 10 bamboo ropes each $6\frac{1}{2}$ in. in diameter. Five similar ropes form each hand railing. The main middle pier is of heavy granite masonry, and the other supports are of hard wooden poles. Small piles are driven into the river bed around them to prevent scouring. The bridge houses, in which are found the usual system of capstans for fastening the ropes, are made of very substantial granite masonry. The floor of the bridge consists of planking held down by bamboo ropes on each side.

Perpendicular strands of bamboo keep the various cables in place, and wooden pegs driven through hardwood poles assist in holding the floor in position. Not a single piece of metal is to be found in the structure. Every year the cables supporting the floor are replaced by new ones, the old cables are transferred to the rails, and the old rail cables are discarded.

Such a bamboo cable, which I had the opportunity of testing, showed a tensile strength of 26,000 lb per sq in.

All these suspension types are found in semi-Tibetan territory and nowhere else in China, so it is tempting to believe them to be of Tibetan origin. However, this belief is probably an error; the Tibetan type of suspension bridge is the same as the Himalayan, the Indo-Chinese, and that found on Taiwan (Formosa)—a type which from an engineering point of view is much more satisfactory than the Chinese. The main cables hang in a gentle curve. To them the deck is fastened by a number of secondary cables so that it is as level as possible. The Chinese, who walk directly on the cables, have probably invented their own type of suspension bridge without alien influences.

Besides the bamboo suspension bridge there is the iron-chain type, of which a number of examples are to be found. Judging from local inscriptions this is not as old as the bamboo-rope type and probably dates from the fifteenth century. The chains are made of heavy hand-forged iron, anchored deep in masonry abutments on both sides. The longest single span of this sort is the Lu Ting Bridge in Szechwan Province, which is 326 ft long. It is constructed of parallel chains covered by a wooden floor 10 ft wide. Another interesting bridge in Kweichow Province has a single span of 200 ft and is supported by 12 chains. The decks of such bridges have no rigidity, so that the structures sway in the wind like hammocks and are consequently impassable during a gale. In order to pacify the donkeys and oxen that carry burdens over them, the hand railings are often covered with bamboo matting or reed plaitings. Since the chains wear badly near the piers, such bridges are often out of use for long periods pending necessary repairs.

The number of Chinese bridges is very large; Marco Polo, who visited the classical Hangchow in the thirteenth century, recorded that there were 1,200 bridges in that city. There are about 300 bridges now in the neighboring town of Soochow, of 600,000 people. There must be more than two million permanent bridges in the 13 provinces, the main Chinese territory.

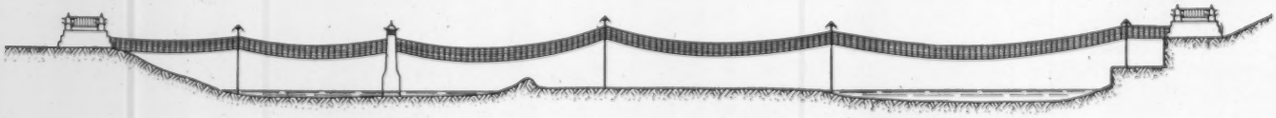


FIG. 8. FAMOUS BAMBOO ROPE SUSPENSION BRIDGE OVER THE MIN RIVER AT KWANHSIEN
Length, 700 Ft; Maximum Span, 200 Ft

Movement of Bed Load in a Forked Flume

Conclusions Drawn from Tests at the U. S. Waterways Experiment Station

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AFTER introducing his subject with a review of the work of previous experimenters in this field, Lieutenant Vogel proceeds to outline the model experiments conducted to date at the U. S. Waterways Experiment Station. An effort was made to have the results applicable to conditions in nature, which previous experimenters had not done. The practical value of an experiment of this nature is to determine the silt-carrying capacity of a small branch which leaves the main stream to rejoin it below, after following a shorter course than the main stream. Within the conditions governing these experiments, the side channel will not be expected to fill with silt. Further conclusions are drawn from the model runs already completed, and recommendations are made as to future procedure for the continuation of these valuable studies.

WHEN the problem of bed-load (*geschiebe*) movement at a stream fork was taken up by the U.S. Waterways Experiment Station in the summer of 1932, a careful study was made of all existing information on the subject. It was learned that the first experiments designed for the express purpose of determining the movements of bed materials at a diversion point in a river were conducted by Prof. H. Thoma of Munich in connection with an extended investigation of power resources of the Mittlere Isar River, as described in his *Modellversuche über die zweckmässigste Gestaltung einzelner Bauwerke* (Charlottenberg, 1923). As a result of model studies he found that in every case tested the percentage of bed material carried into the branching channel was much greater than the percentage of water going down that channel.

EXPERIMENTS AT KARLSRUHE

Recognizing the importance of these findings and appreciating the desirability of continuing the investigation from a more theoretical standpoint, Professor Rehbock, Director of the River Hydraulics Laboratory of the Technical University at Karlsruhe, sponsored a series of tests which were carried out under the direct supervision of Dr.-Ing. Hermann Bulle. Dr. Bulle's experimental flume was designed to include five angles of diversion between 30 and 150 deg. In total length it measured 21.15 ft, and its diversion point was 8.22 ft from the upstream end. The length of the side channel was equal to that of the main channel below the point of diversion. Both channels were given a rectangular cross section, a width of 0.656 ft, and a bottom slope of 0.003. Adjustable weirs were employed as tailgates at the downstream ends of the two channels, and a sharp-crested, rectangular weir was installed at the entrance end of the main channel to provide accurate measurements of inflow.

Bed material was introduced by Dr. Bulle at the upper end of his flume at a constant rate, and after a given time interval the amount deposited in the respective channels was collected and measured. The experimental arrangement was such that only the bed material deposited in the channel could be measured. Thus no cognizance was taken of, and no studies were made on, the material moving through the channels. The maximum discharge recorded during the entire series of tests was 0.28 cu ft per sec.

In *Untersuchungen über die Geschiebeableitung bei der Spaltung von Wasserläufen* (Berlin, 1926), Dr. Bulle summarized his results and findings substantially as follows:

1. Just inside the branching channel and opposite the point of diversion, a roller or eddy was formed. This roller varied in size with the angle of diversion and with the form of the diversion point. It acted to contract the section of the branching channel, and so to increase slopes at its mouth.
2. For small angles of diversion and small discharges, with the two tailgates set at the same elevation, the quantity of flow was about equal in each channel. For greater discharges, somewhat more water was carried down the straight channel. The least water was carried by the side channel when its angle with the main flume was 90 deg.
3. The least deposition of bed material was noted in the side channel when its angle with the main channel was 120 deg, but even in this case 87.5 per cent of the total was carried into it and deposited.
4. When the angle of diversion was 30 deg and the tailgates were at the same elevation, there was little tendency for any of the bed material to continue in a straight line past the point of diversion; but by manipulation of the tailgates so as to increase greatly the flow in the main channel and to decrease correspondingly the discharge into the side channel, more material could be made to move down the straight channel. As compared with the percentage of water carried by the side flume, the percentage of bed material deposited was always very large.
5. A rounded corner at the convex side of the entrance to the side channel (tested only for angles of 30, 60, and 90 deg) tended to decrease the contraction of the side channel produced by the roller, and at the same time to decrease the transverse slope at the point of diversion. More water but less bed material were carried into the side channel as a result of the rounded corner.
6. With equal discharges in the two channels, a decrease of one half in the width of the side channel did not produce a proportionate decrease in the bed material carried into that channel.

PRELIMINARY EXPERIMENTS OF THE U.S. WATERWAYS EXPERIMENT STATION

As a result of its study of previous experiments on the movement of bed load in a forked flume, the U.S. Waterways Experiment Station decided to conduct preliminary experiments along the same general lines as followed by Dr. Bulle. These experiments were un-

dertaken in July 1932, by K. D. Nichols and C. D. Curran, Jun. Am. Soc. C.E., Lieutenants U.S. Army, at the U.S. Waterways Experiment Station, under the immediate supervision of the Director. In Table I are given the dimensions of the flume employed in these preliminary studies as well as those used in Dr. Bulle's experiments.

At the Vicksburg Experiment Station each flume was of rectangular section, and in every case the sections of the side and the main flume were the same. No sand traps were provided in either, and no attempt was made to control the roughness of the channel sides. Two kinds of material were used: loess to show the effects of silty soils carried largely in suspension, and sand from the Red River to show the effects of relatively heavier material. Table II gives data on the experiments with sand and Table III shows the relative effects of sand and loess transported by the flowing water.

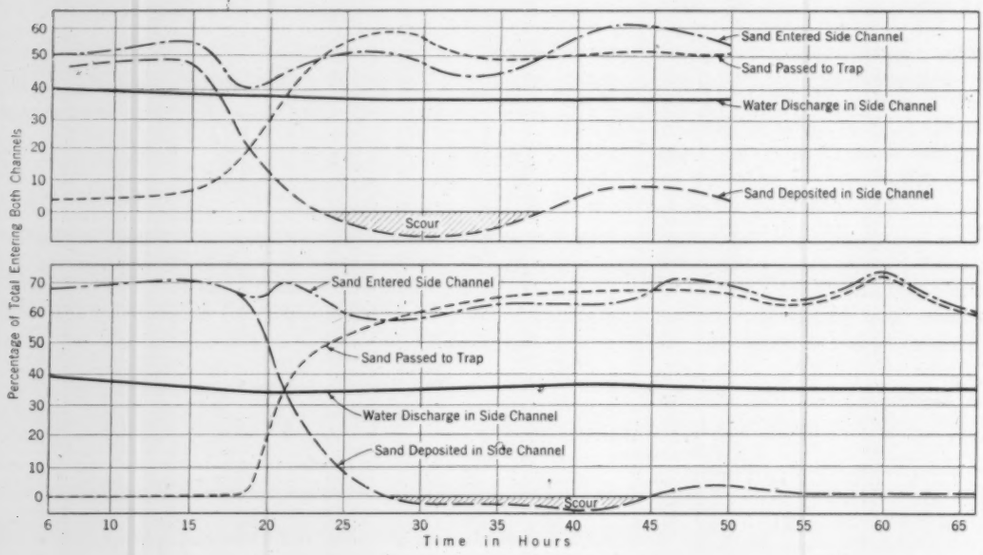

Sand Entered Side Channel
Sand Passed to Trap
Water Discharge in Side Channel
Sand Deposited in Side Channel
Scour
Percentage of Total Entering Both Channels
Time in Hours

FIG. 1. EFFECT OF TIME ON DISCHARGE AND MOVEMENT OF GESCHIEBE
Above, with Fine Red River Sand, Sand Experiment No. 2. Below, with Coarse Polk Creek Sand, Sand Experiment No. 3

TABLE I. COMPARATIVE DATA ON TEST FLUMES

ITEMS	U. S. WATERWAYS EXPERIMENT STATION, VICKSBURG Nichols-Curran	TECHNISCHE HOCHSCHULE, KARLSRUHE Bulle
Total length of straight channel	22.0 ft	21.15 ft
Distance from head of flume to point of diversion	10.2 ft	8.22 ft
Width of each channel	2.0 ft	0.66 ft
Angle of diversion	30 deg	30, 60, 90, 120 and 150 deg

TABLE II. RUNS WITH RED RIVER SAND, Q A VARIABLE

RUN NO.	Q Cu Ft Per Sec	V ABOVE DIVERSION Ft per Sec	PERCENTAGE OF Q		PERCENTAGE OF GESCHIEBE	
			In Straight Channel	In Side Channel	In Straight Channel	In Side Channel
1	0.755	0.968	35.0	65.0	14.9	85.1
2	0.767	0.994	50.6	49.4	24.1	75.9
3	0.767	0.936	51.2	48.8	24.8	75.2
4	0.755	0.980	65.1	34.9	36.4	63.6
5	0.755	0.945	69.8	30.2	54.7	45.3
6	0.753	0.952	70.1	29.9	48.7	51.3
7	0.753	1.004	75.8	24.2	62.9	37.1
8	0.745	0.940	76.7	23.3	61.8	38.2
9	0.758	1.009	84.1	15.9	82.1	17.9

As a result of these preliminary experiments, the following conclusions were reached which, in so far as they may be compared, agree with the results of Dr. Bulle:

1. At a stream fork, natural or artificial, where the channel sections are approximately rectangular and the *thalwegs* are of approximately the same elevation, it may be expected that in relation to the discharge of the respective channels, a greater proportion of the bed load will move into that channel which is at an angle to the straight reach.

2. Material carried in suspension will be distributed differently from that moved by traction along the stream bed. This is a point not touched on by previous experimenters.

3. The deepest water will be found on the inside of the fork in both channels.

LATER EXPERIMENTS

The preliminary experiments just described were begun in July 1932 and completed in September of that year. A consideration of their results and of the work of earlier experimenters led to the following conclusions:

1. Experiments which indicated greater movement of bed material into the side channel of a river system had been performed under limited conditions. Thus, it had been well established that when both channels have the same depth and section throughout, greater movement occurs initially into the branch, but no cognizance had been taken of the element of time, and nothing had been shown as to what ratio of movement might be expected after a bar had formed across the mouth of the side channel.

2. All previous experiments had been conducted with small flumes of rectangular channel section, in which the frictional effects of sides and bottoms were relatively large. Would the results obtained from a more generous set-up and from non-rectangular sections agree with those of the earlier investigations?

TABLE III. SAND AND LOESS RUNS COMPARED

RUN NO.	MATERIAL	Q Cu Ft per Sec	V Ft per Sec	PERCENTAGE OF Q IN SIDE CHANNEL	PERCENTAGE OF BED MATERIAL IN SIDE CHANNEL
1	Loess	0.774	0.925	51.2	55.1
2	Sand	0.767	0.936	48.8	75.2

3. In the experiments of Dr. Bulle only one type of sand was used, and its mechanical properties were not shown by him. The preliminary experiments of the U. S. Waterways Experiment Station concerned materials carried in suspension as well as those carried along the bottom by tractive force. It is evident that the mechanical properties of a *geschiebe* may have a great influence on its behavior.

As a result of these considerations it was decided that the flume for subsequent experiments should be: (1)

of greater length and of semicircular cross section, (2) designed with the branch channel smaller than the main channel, (3) lined with cement mortar to procure a uniform frictional resistance throughout, and (4) equipped with sand traps at each downstream extremity to provide a means of measuring the sand moved completely through the flumes, an improvement of great importance since it permits runs of indefinite duration to show the ultimate development of any particular set-up.

EXPERIMENTAL FLUME DESCRIBED

In accordance with these considerations, designs were prepared for a main flume of 2-ft cross-sectional radius, intersected by a side flume of 1-ft radius. The over-all length of the main flume was 32.635 ft and the point of intersection was 11.235 ft from the head. The bottoms of both channels were laid on the same horizontal plane. The angle of bifurcation to be tested was selected as 30 deg, because it represented an average condition found in nature. This fact was determined by consulting maps and surveys of the Mississippi River.

The two sand traps were of equal size, 3.5 ft wide by 4.0 ft long and deep enough so that their bottoms were 1.25 ft below the bottoms of the flumes. On the downstream side of each sand trap an adjustable tailgate was mounted to provide for the regulation of outflow during the progress of the experiment. Whereas for the first test these gates were made rectangular and provided with steel edges at their crests, later they were cut to conform in shape to the cross sections of the respective channels. Semicircular steel edges were then added to ensure an unvarying flow.

Water for the experiment was brought by an 8-in. pipe from the large outdoor reservoir of the Experiment Station to a weir box installed above the upstream end of the flume. A stilling chamber with two baffles and screens was built between the weir box and the flume to ensure a quiet entrance. At the downstream end of the main flume a second weir box was provided for the measurement of outflow from that channel. Since the inflow and outflow of the main channel were known, the outflow of the side channel could be readily determined, and no measuring device was deemed necessary at its downstream extremity. The weir plates of both the upper and the lower weir box were of the 90-deg, V-notch type. Heads were measured by hook gages in the side wells connected by pipes to the weir boxes. Water-surface elevations in the flumes were measured in the same way, and in addition point gages were used as a check.

To establish a basis of comparison for subsequent tests and thus indicate the source of variations in water-surface profiles and also to calibrate the weirs with respect to each other, a plug was inserted at the entrance of the side channel, so that the entire discharge passed down the main channel. Under this set-up it was found that there were no irregularities of flow in the main channel and that the slope was uniform throughout.

DETERMINATION OF FLOW CHARACTERISTICS

With no bed load in the flume, and with both tailgates set at the same elevation, observations were made for a discharge of 1.0 cu ft per sec to determine the division line between flows to the two channels. A solution of potassium permanganate injected into the flowing water showed that there was a pronounced roller at the right side of the entrance to the side channel. This roller had a vertical axis, turned in a clockwise direction, and extended beyond the center line of the channel.

On the left side of the diversion channel, downstream from the bifurcation of the water, there was a violent eddy, the outline of which was marked by a series of small vortexes. The greatest velocity in the side channel was observed between the roller and the eddy.

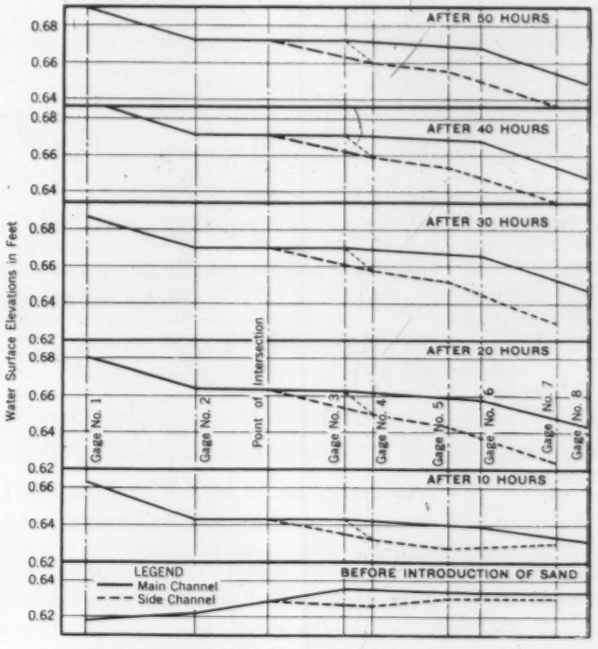


FIG. 2. WATER-SURFACE PROFILES DURING SAND EXPERIMENT NO. 2
Total of 73.5 Cu Ft of Fine Red River Sand Introduced

On the left side of the main channel was found another roller the outline of which was difficult to determine but within which a definite counter-clockwise motion was observed. Its internal velocities were small, however, as compared with those of the roller in the side channel.

Sand Experiment No. 1 was discontinued at the end of 16.5 hr because of the great slowness of bed-load movement. A finer sand was selected for Sand Experiment No. 2.

In the second sand experiment, the two tailgates were set at the same elevation, and the total discharge was 1.500 cu ft per sec. Red River sand was employed, the total amount introduced being 73.5 cu ft. The experiment consisted of 7 runs of 7 hr each. The sand was carefully fed in by hand at the upper end of the flume in such manner that an absolute minimum was put in suspension. A measured volume of 0.25 cu ft was distributed across the channel every 10 min, and water-surface elevations were taken every hour. The weir gages were also read every hour. After each run the model was drained, the sand held in the sand traps was measured, and cross sections were taken of the sand deposits in the flume.

Careful measurements made throughout the course of all seven runs revealed that the flow in the main channel downstream from the point of diversion increased gradually and slightly up to the time stability was reached, but that thereafter the ratio of flow in the two channels remained practically constant, as shown in Fig. 1. During the first 20 hr, variations in water-surface elevation and in slope were very irregular. Between the twentieth and the thirtieth hour stability

was approached, and after 30 hr practically all changes ceased and increases in elevations became very small. The variations in water-surface elevation are indicated in Fig. 2, which shows actual slope profiles as recorded throughout the test.

It was noted that during the first few hours of the experiment both channels filled rapidly, and that de-

TESTING EQUIPMENT AT U. S. WATERWAYS EXPERIMENT STATION
View Looking Upstream

posits were about equal in volume. The sand deposit worked itself to the end of the side flume and caused an influx to the sand trap before a similar effect was noted in the main channel, with the result that for a time greater quantities were measured in the former trap. When stability had been reached, after 30 hr of running, the subsequent tendency was for nearly constant quantities to be carried through to the two traps. At the same time there was a decided tendency for the two channels to maintain their bed deposits at a point about equal to that at the end of 28 hr.

In Sand Experiment No. 3 the two tailgates were set at the same elevation as in the two previous sand experiments. The total discharge was 1.500 cu ft per sec. Polk Creek sand to the amount of 66 cu ft was employed. The experiment consisted of 11 runs of 6 hr each, a total of 66 hr.

Careful measurements were taken at the end of each run to determine the amount of material carried into and through the side channel. The methods described for Sand Experiment No. 2 were followed. Toward the end of the experiment more than 95 per cent of the sand introduced was being accounted for, thus indicating that little or none was being carried in suspension. This percentage is significant in view of the fact that in Sand Experiment No. 2 only about 50 per cent of the total sand introduced was eventually recovered.

DISCUSSION

In simple form, the curves of Fig. 1 present the gist of all that was observed during the last two experiments. It will be noted that the distribution of water remained practically constant throughout each test and that the percentage of bed material entering the side channel likewise remained substantially constant. The percentage of material deposited and that of material moved through the channels vary inversely, as would be expected.

When the curves of Sand Experiment No. 2 are compared with those of No. 3, it will be observed that in each test the amount of material entering the side channel is nearly unchanging from start to finish. In both cases the channels filled to a point of stability before any large quantities were caught in the sand traps at the extremities, although the Polk Creek sand tended to move in waves instead of building up horizontal layers as did the Red River sand. The variation in coarseness of the two sands probably accounts for this and also explains why different percentages of material entered the side channel in the two experiments. The coarser Polk Creek sand was moved by traction along the bottom, whereas the finer Red River sand was carried partially in suspension and therefore tended to separate in proportion to the flow of water into the two channels. Verification of this statement is found in the fact that of the 73.5 cu ft of Red River sand introduced during the progress of the second experiment, only 49 cu ft was eventually recovered, but in the case of the Polk Creek sand 64 cu ft was accounted for of a total of 66 cu ft introduced.

In Sand Experiment No. 2 about 52 per cent of the sand went into the side channel while 48 per cent followed the main channel; in Sand Experiment No. 3 the percentages of material passing into side and main channels were 65 and 35, respectively. Thus in the former case less bed material was diverted from a straight path than in the latter. Except for this difference, the characteristics of the corresponding curves (Fig. 1) are fundamentally the same and both indicate that the percentage of the total bed load entering a side channel is constant. This, of course, is based on the assumption that the slopes within that channel result in tractive forces adequate to maintain movement.

The data from Fig. 1 for the percentage of sand diverted into the side channel differ from those of Professor Rehbock and Dr. Bulle, but it should be remembered that in the earlier experiments the two flumes had rectangular sections of equal area, and that discharges in the two were likewise maintained equal. In the later tests of the U.S. Waterways Experiment Station, semicircular cross sections were employed and the side channel was given an area two-thirds that of the main channel, with a correspondingly smaller discharge.

SLOPES OF SIDE AND MAIN CHANNELS IN VICKSBURG MODEL EXPERIMENTS

In all the sand experiments at the Vicksburg Station, the slopes in the side channel were steeper than those in the main channel. These experiments were therefore representative of the conditions found in a natural river at a reach where a small branch leaves the main river at an angle of 30 deg to rejoin it below in such manner that the branch is shorter than the main stream. The experiments showed conclusively that beyond a definite limit no filling of the side channel might be expected, and it may be reasoned that any later development of the branch will occur as the result of widening rather than deepening of the mean section. It should be remembered that in the experiments a

constant rate of flow was maintained in the main channel above the diversion, a condition which would not obtain in nature.

These studies did not include the case of a flatter slope in the side channel than in the main. Such a case represents the situation encountered in nature where a cut-off has become the main river channel and the abandoned channel is carrying a small part of the total discharge. The tendency then is for deposits to occur rapidly at each end of the old channel and for the flow through it to be progressively decreased until the old channel exists only as an ox-bow lake. Thereafter the only deposition within it will be by sedimentation following overflows from the new main channel. These tendencies have been noted in model studies of problems involving long chutes at the U. S. Waterways Experiment Station.

CONCLUSIONS SUMMARIZED

Important conclusions derived from the experiments of the U. S. Waterways Experiment Station follow:

1. In the case of a side channel with surface slopes greater than those in the main channel, a nearly constant percentage of the bed load passes into the side channel.
2. As compared with the percentage of total flow down the side channel, the percentage of bed load carried by it is large.
3. The distribution of the bed load is a function of the mechanical composition of the material. The finer the material, the more it tends to move in suspension, and the greater is its tendency to divide in the same proportion as the water.
4. As regards slopes it has been found that: (*a*) when all the flow goes down the main channel, slopes are uniform and positive, as in the ordinary open channel; (*b*) when there is flow down both channels, but no bed load in the flume, negative slopes occur in the main channel and those in the side channel are comparatively flat; (*c*) the introduction of bed load creates a readjustment of the slopes; negative slopes disappear and steeper slopes occur in the side channel.
5. Flow characteristics may be summarized as follows: (*a*) when there is flow down both channels, and before the introduction of *geschiebe*, a roller is formed just inside the entrance to the side flume, this roller having the effect of reducing the effective cross-sectional area of the channel, with a corresponding increase in mean velocity; (*b*) with the introduction of *geschiebe* this roller in the side channel disappears, but higher velocities continue to exist between the area previously occupied by the roller and the opposite side.

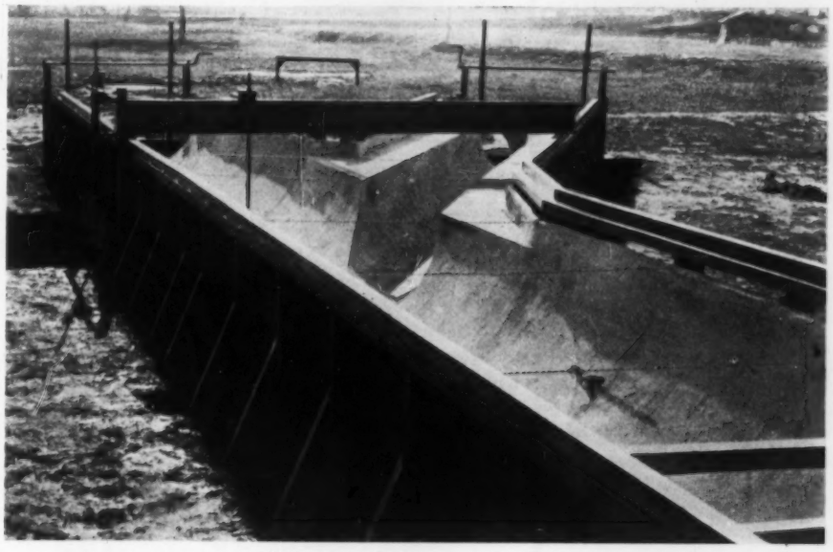
Experiments were conducted at Cornell University by Lieutenants Nichols and Curran under the immediate supervision of E. W. Schoder, M. Am. Soc. C.E., Professor of Experimental Hydraulics, Cornell University, as a continuation of the preliminary tests performed at the U. S. Waterways Experiment Station. The equipment was similar to that used previously at the U. S. Waterways Experiment Station, but a coarser sand was employed to eliminate transportation of fine particles in suspension.

In addition to obtaining substantiation of the conclusions reached in the preliminary experiments conducted at the Experiment Station, the following observations were made in general corroboration of the findings of later tests reported upon in this article: (1) With the introduction of bed load the roller or eddy in the side channel disappeared and a bar was built up in its place. (2) The percentage of bed load deposited in the side flume increased between the second and the fourth hour, decreased between the fourth and sixth hour, increased between the sixth and eighteenth hour, and remained constant between the eighteenth and twenty-fourth hour. Because of the length of the side flume and the absence of sand traps, 24 hr was the maximum time taken for any test. (3) The percentage of water flowing down the side channel decreased slightly with the passage of time for all tests of 24-hr duration. (4) For tests of short duration (6 hr) the percentage of bed load deposited in the side flume increased with an increase in slope throughout the flume. Such increase in slope was obtained by lowering the tailgates of the two flumes.

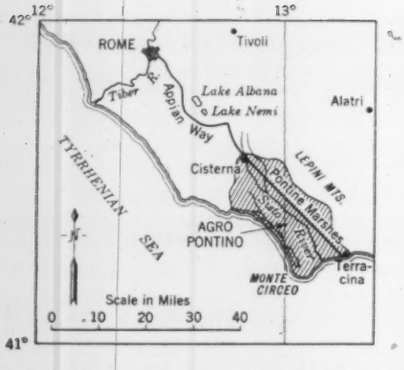
RECOMMENDATIONS FOR FUTURE TESTS

The studies of the U. S. Waterways Experiment Station have carried the important problem of the action of bed load at a stream fork several steps nearer its final solution. The apparatus used and the technique developed have given excellent results and seem entirely adequate for a thorough investigation of the problem in all its aspects. It appears that the next phase of the investigation should aim to determine: (1) the effect of varying the total inflow to the flume, (2) the effect of varying the slopes in the respective channels, (3) the effect of various entrance conditions for the side channels, (4) the effect of different cross-sectional relationships, (5) the effect of varying the angle of diversion, and (6) more definite relationships between the action of a bed load and its mechanical analysis.

Throughout all the experiments the application of the results to the problems encountered in nature will be kept in mind. It is believed that facts of great practical value have already been derived from these studies and that many more will follow from their continuation.



FORKED FLUME AT U. S. WATERWAYS EXPERIMENT STATION, VICKSBURG
Semicircular Mortar-Lined Flumes, 2 Ft and 1 Ft in Diameter, Intersect at 30 Deg



Historic Pontine Marshes Drained

Government Reclamation Project Near Rome, Italy, Now Nearing Completion

By Herbert H. Wheaton

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Associate Professor of Engineering and Mathematics,
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With a twofold purpose in view, the Italian Government is completing the drainage of the famous Pontine Marshes, a fever-infested region to which Roman political and religious prisoners were banished in centuries past. The reclamation of this 187,000-acre area, through which the Appian Way passes, not only gives work to Italy's War veterans and later will provide farms for them, but also eliminates the serious malarial menace that has persisted since the time of Caesar. Four separate canal systems with their pumping plants drain the areas below sea level, lower the water table, and provide irrigation water during the growing season. More than half the total estimated cost of $35,000,000 is being borne by the Italian Government. The remainder will be paid by the settlers under a system of long-term loans. While studying in Europe as a Freeman Traveling Scholar of the Society, Mr. Wheaton was conducted over the entire district.

SINCE Roman times, the broad coastal plain which lies to the south of Rome, Italy, has been a serious menace to the Eternal City because of the ever-present danger of the spread of malaria. Four years ago the Italian Government, through the Bureau of Saltmarsh Reclamation, began the drainage of this area of 187,000 acres, including the Pontine Marshes, as shown on the accompanying map. In the short period between 1929 and 1933 the major parts of the project have been completed or almost so. Under the previously mentioned bureau, the work is being carried out by two organizations representing the two districts into which the area is divided, the Consorzio Bonifica di Piscinara and the Consorzio della Bonificazione Pontina.

In May 1933, Chief Engineer Enrico Nasi, of the latter organization, conducted me over the entire district. This drainage project is one of a large number of similar activities along the Italian coast. Through the reclamation of such marsh areas not only will the ever-present malarial menace be eliminated, but a great deal of land will be brought under cultivation, which in Italy at the present time is highly desirable. The area lies between the shore of the Mediterranean Sea and the abruptly rising hills about 10 miles back from the shore. It begins at a point about 30 miles southeast of Rome and extends along the coast about 30 miles to the city of Terracina, at which point the Lepini Mountain Range terminates at the sea. The famous Appian Way of the Romans enters the area at Cisterna di Roma and leaves it at Terracina. Ever since Roman times most of the region has been but sparsely settled or uninhabited because it was a breeding place for malarial mosquitoes. Numerous epidemics have been traced to this source. Most of the people who inhabited the region died of the fever or were forced to flee.

Italy is carrying out the project entirely by the employment of its ex-service men. Four years ago the area was nearly an impenetrable morass; today it is almost entirely a well-drained agricultural area and a safe and pleasant place to live. The land is almost level. About one quarter of it is so low that drainage water must be pumped from the collection canals to the sea, and large areas lie below sea level. The entire coast line is a sandy beach behind which rises a ridge of sand dunes so continuous that the water flowing down from the nearby hills or rising from springs cannot escape to the sea. Behind the line of sand dunes there is therefore a row of bayou lakes, shallow and full of marsh vegetation. Several low ridges a few feet above sea level extend across the district, but they are so broken by swales and ravines, usually filled with stagnant water, that they are unfit for habitation. Large areas not subject to submergence have been forested, and other sections near the coast at one time not submerged and forested have since become submerged, and are now a mass of tree stumps. A large part of the area is covered with soil consisting of decayed vegetable matter, the result of its being for a long period in a marshy condition. Much of the region contains peat in its first stages.

About one quarter of the area was successfully drained by the Romans, who had a harbor at one point along the coast. Their old system of drainage has fallen into disuse, but many of the channels can still be followed, and in one place I saw one of their rock-walled canals still giving good service as a drainage ditch. A considerable area was drained about four hundred years ago by order of the Pope, through canalization of the Sisto River, which flows almost the length of the project, about halfway between the hills and the coast, and empties into the sea at the southern end of the area. This system of canals is today being enlarged, and the Sisto will be one

A Bridge Over the Mussolini Canal on the Appian Way
One of the Many Bridges Built on the Drainage Project

of the main drainage channels of the new system. The Sisto canal system drains principally the sections along the Appian Way.

PROVISIONS FOR DRAINAGE AND IRRIGATION

As shown in Fig. 1, the drainage system under construction includes four types of canals. The largest are those which serve only to carry to the sea the water of the streams rising in the hills behind the low land. A few feeders drain water into these channels, and some water from low-lying areas is pumped into them, but in general they serve only the one purpose. The second canal system drains that part of the region from which water can be carried entirely by gravity to the ocean, and serves also to carry off the water of a number of large springs which rise near the base of the hills. These canals drain about half the area and will have three principal outlets to the sea. The other half of the area is served by canal systems of the third class, which drain areas so low that pumping is necessary. At four points pumping plants will lift water from this last group of canals directly into the sea, and at many other points water will be lifted from these channels to the canals of the second type, whence it will flow to the sea by gravity.

A SHOVEL AT WORK CANALIZING THE RIVER SISTO, TWO MILES FROM THE SEACOAST

The Water-Filled Channel Was Built by Papal Authority About 400 Years Ago

FIG. 1. PLAN OF DRAINAGE AND RECLAMATION OF THE PONTINE MARSHES NEAR ROME, ITALY

187,000-Acre Italian Government Project Constructed by Ex-Service Men at a Cost of $35,000,000

DREDGING THE RIVER SISTO THROUGH THE SAND DUNES BACK OF THE BEACH

The Pumping Plant Seen in the Distance Will Lift the Drainage Water so That It Will Flow by Gravity to the Sea

In addition to the three pumping plants previously existing for drainage, 14 new ones will be built to serve the low-lying canals. The fourth canal system is required for the irrigation of areas lying along the low ridges.

All the irrigation water will be derived from a spring near the base of the hills. The main canal will have a capacity of 150 cu ft per sec and will traverse the entire length of the district, crossing the drainage canals by means of overpasses or underpasses at many points. Four pumping plants will be constructed to lift irrigation water to higher levels than can be reached by the canal. Although the annual rainfall is about 40 in., there is almost none in July and August; so that irrigation at higher levels is essential. The capacity of the irrigation canal is small, but since the water will be distributed by rotation to the several parts of the system, and not on demand, the quantity carried will be sufficient. In a few places water can be taken from the drainage canals for irrigation.

Canals for land drainage are supplied with a large number of drops, which are usually built of concrete with stone facing, and are generally of the notched type. In order that the underdrainage may not lower the water table too much, the gradients of the ditches must be altered to fit the general slope of the country through which they pass. The drops are necessitated by the difference in gradient of the various parts of the canals. When the drainage canals pass through areas where local surface drainage might run into the canals, small interception ditches are run parallel to the banks. The larger ditches are built with berms on the inside, so that in periods of low flow the water will be confined to a narrow channel, thus increasing the velocity and lessening the danger of the growth of aquatic plants. All low areas where the water table cannot be brought below the surface by drainage will be filled in until the water table is sufficiently far below the surface to permit the raising of crops.

Although the drainage of the bayou lakes near the seashore might completely eliminate the malarial danger in their vicinity, it has been considered sufficiently safe to deepen them to such an extent that aquatic plants will not grow in them, and to line the shores with steep stone embankments. The deepening is being done by suction dredges, which are pumping the muck to the areas surrounding the lakes, raising them to a safe height above the water table. The lakes are important for fishing, and it was not deemed advisable to destroy this industry, from which an income of one million lira (about $50,000 at par) per year is derived. The pumping plants in the vicinity of the lakes will be so arranged that these bodies of water can be kept at a constant level throughout the year.

Where water from the larger drainage ditches is delivered to the sea by pumping plants, it is raised to high levels in the sand-dune ridges, whence it flows through lined ditches to the shore. For about a hundred yards beyond, it is confined between concrete walls built on concrete piles. These walls serve to keep the sand that shifts along the shore from blocking the outlet channel of the canal.

VILLAGES, FARM HOUSES, AND ROADS BUILT

Seven villages for the housing of employees and to serve as headquarters and supply points have been built by the bureau. The largest of these is Littoria, which was begun only during the past year but already has many beautiful and substantial stone, brick, and stucco buildings. Among these are the administration building of the district, a school, a church, a post office, an auditorium, a cinema, a hotel, and an office and store building. Many houses for those now at work on the project and for potential settlers have been constructed in the town. However, most of those who will develop the land will live in individual houses on the farms. Hundreds of farm houses and other accessory buildings have been erected by the district. All are comfortable two-story dwellings, one to each section of approximately 40 acres.

For the past two years all the drained land has been placed under cultivation, mostly by the districts in large farms. The principal crops have been grain and hay. In addition, many cattle have been pastured. As the project is brought to completion, however, and the individual farm buildings are made ready for occupation, families will be settled on the 40-acre tracts, and diversified farming will commence.

Three hundred miles of roads have been built by the districts, some hard surfaced and the rest graveled. All are well graded and drained. Many pass over what a year or two before were impassable swamps. Now it is possible to drive at high speed over the entire area. All the bridges and culverts are built of stone or stone-faced concrete and present an attractive appearance. The cost of developing the two projects will be roughly 600,000,000 lira, or approximately $35,000,000. More than half the expense will be borne by the Italian Government in view of the facts that the work is for the public health and welfare and that it serves as a means of employing veterans of the War and establishing them on farms. The remainder will be borne by the settlers themselves, in the form of long-term loans.

I visited the houses of some of the people who for several hundred years have defied the fever and inhabited the district. They were crude buildings, and gave evidence of the hard life their owners lived. The ancestors of these families were political or religious prisoners in Rome, who were given their freedom on the condition that they would remain in this fever-stricken region.

DRAINAGE OF LAKE NEMI

A visit to the celebrated Lake Nemi, which lies between the reclamation project and Rome, is also worthy of mention. This lake, once a volcanic crater at the edge of the hills, in Roman days was connected to the sea 12 miles away, both by a tunnel through the crater wall and by canals. By these means the Romans could bring their galleys into this entirely landlocked harbor. Two of the old galleys which had sunk in the lake were desired a few years ago as relics because of their excellent state of preservation. The old Roman tunnel, which had caved in, was therefore opened up enough to permit the pumping of water out through it, and the lake level was lowered about 40 ft. The galleys now lie on the bank, where they are being restored.

Our party motored back to Rome over the Appian Way, past the ruins of the old Roman aqueducts and along the highway over which Caesar's legions marched and his chariots clattered. But the driver of our car sped over the excellent modern Appian Way at 60 and even 70 miles an hour.

RELICS RECOVERED FROM ROMAN BARGES SUNK IN LAKE NEMI

A Figurehead and Two Types of Rings Attached to Ends of Timbers for Mooring the Barges or Moving Them. The Excellent State of Preservation of These Castings Is Apparent. Photographs by Guido Bernardi, Rome

Erosion and Watershed Protection

A Résumé of the Problem in Its Practical Aspects

By W. G. Hoyt

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Hydraulic Engineer, U.S. Geological Survey, Washington, D.C.

IN the field of watershed protection against erosion, the engineer is an active but impartial contestant in the continuous conflict between the forces of nature and the works of man. From intimate contact with this problem, Mr. Hoyt divides the watersheds of the country into four general types according to their erosion characteristics, outlines the changing conditions, and describes remedial measures being taken to provide stability. He believes that although the engineer has contributed to excessive erosion but little in the way of cause, yet he should play an important part in providing a cure.

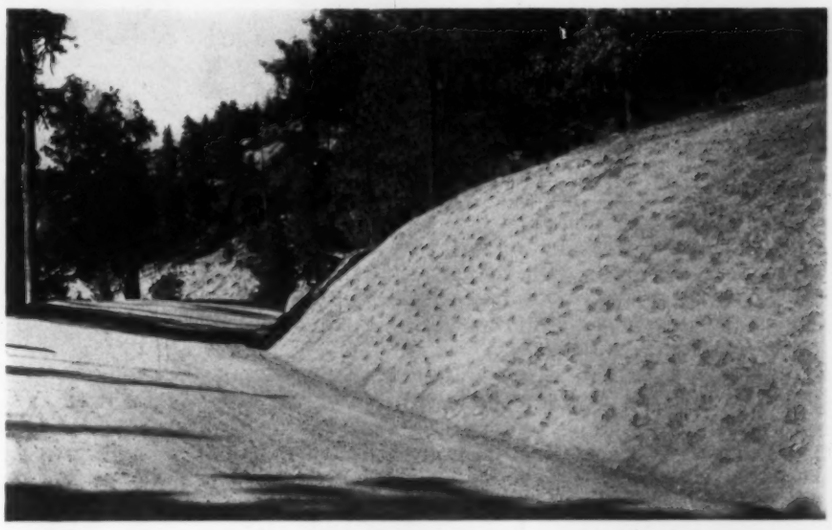
ALL land and water surfaces in the United States are a part of some watershed. Their surface features are not stable; "change and not stability is the order of nature." On some watersheds the changes occur so slowly that they are imperceptible within a lifetime. On others they are rapid and violent. Whenever the changes are of such magnitude that they affect man's occupancy and endeavor, they excite man's interest, especially when the effect is adverse. Whether past changes in the United States have been mainly beneficial or mainly detrimental is not relevant to the present discussion. Present changes are in general likely to be detrimental, considered in their temporary aspects, because in our civic and agricultural development little effort has been made to avoid areas where natural changes are known to be occurring, or where they can reasonably be anticipated. To what extent are these changes natural and inevitable? To what extent are they caused by man? What can be done about them? All these are pertinent questions.

Aside from changes resulting from earthquakes, volcanic eruptions, and other similar disturbances, the greatest change in the surface of watersheds results from the transportation of material by water, ice, or wind. In transportation by water or ice, material is transferred from a higher to a lower altitude and eventually may pass out of the watershed. In transportation by wind, the material is moved in the direction of the prevailing wind and may likewise eventually be carried out of the watershed. The amount of material moved depends largely on its resistance and on the magnitude and velocity of the propulsive force. It is evident that under any given set of conditions an increase in the disintegrating or transporting forces or a decrease in the resistance of the material results in an increased movement, and the reverse results in a decreased movement.

It may be asserted as a principle that the forces of nature which break down, disintegrate, and transport the surface material of a watershed are positive and their application is continuous. The rate of disintegration and transportation is however variable and even eccentric, depending on and changing with precipitation, temperature, soil, topography, and vegetation. The character and degree of application of these factors vary widely. The mean annual precipitation ranges in different areas from practically nothing to over 100 in.; the temperature, from arctic to tropic; the surface material, from dust to coherent rock; the topography, from level plains to precipitous slopes; and the vegetation, from desert shrubs to olympic forests. Moreover, climatic conditions and vegetation are subject to seasonal, annual, and cyclic changes.

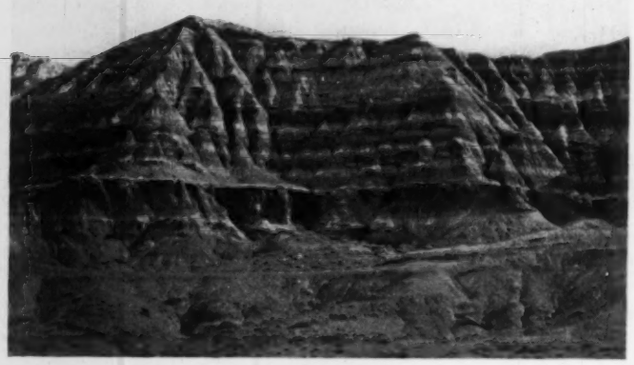
Any watershed, therefore, is subject to cycles and epicycles of aggradation and degradation—a tearing down in one place and a building up in another, with a natural tendency for the surface to approach a level plain as a limit. In some watersheds the adjustment between the forces of nature that cause the changes and the resistance of the surface to change is so stable that agriculture, grazing, or lumbering have little apparent effect. In other watersheds the adjustment is so delicate that marked changes apparently follow man's occupancy. The term "apparently" is used advisedly, for in some areas the periods of man's occupancy seem to coincide with natural cycles, making it difficult, if not impossible, to ascribe definite reasons for the changes noted.

If it can be admitted that over a very considerable part of the United States there are no appreciable artificial changes in surface characteristics as a result of man's activities, and therefore that there is no outstanding problem of watershed protection, and if it can also be admitted that over another, though much smaller part, the natural changes are so great that little can be done about them, the scope of the problem is greatly limited.



Roadway Cut Sloped and Pocketed Ready for Planting of a Protective Covering

No one questions the fact that human activities in clearing and cultivating the soil, in utilizing the resources of the range, and in harvesting forest products tend to lessen the resistivity of the soil to movement and



EROSION IN THE BAD LANDS ON THE WIND RIVER, WYOMING
Hayden Survey, About 1870

thus hasten the natural process of leveling. These activities are necessary to human existence, however, and the benefits received must be weighed against the resulting detriments. In many parts of New England, New York, Pennsylvania, New Jersey, Florida, Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, and Idaho, and in parts of North and South Dakota, Montana, and the Pacific Northwest there is little evidence to show that the extensive activities of man have materially aggravated natural changes.

In certain areas of these states changes have occurred which have resulted in devastated land. Over other large areas relatively little agricultural land has been damaged either by erosion or by accretion. Reservoirs across watercourses have maintained their efficiency, and the transporting power of the rivers has not been materially impaired. Exclusive of the lessening of soil fertility, which can be artificially restored, it seems reasonable to assume that the benefits received from man's activities in these areas far outweigh any damage which artificial changes may have produced. In general, therefore, in these areas there is no outstanding problem of watershed protection. Local communities may wish to maintain natural conditions on watersheds used for recreation or municipal water supply, and in certain areas farmers may find it necessary to take extraordinary precautions in their practices of cultivation and cropping to prevent undue surface washing. By and large, however, there seems to be in many parts of this broad region no serious problem of watershed protection that cannot be handled by local communities or individuals.

At the other extreme are parts of Arizona and Utah, especially the non-arable areas tributary to the Colorado, Little Colorado, San Juan, and lower Green rivers, where the natural changes in the surface of the watershed are so great that it seems inconceivable that over wide areas the activities of man measurably affect them. Precipitation, when it occurs, is torrential. Vegetation, as commonly understood, is practically absent or else the soil offers little resistance to movement. Such agricultural activities as exist in these areas are largely confined to grazing. Few people even attempt soil husbandry in these sections. Highways and railroads adjacent to watercourses are in constant jeopardy, and in the planning and construction of reservoirs it is realized that their effective life is limited. To do otherwise would be to disregard the inevitable. In these and other areas, such as the "bad lands" of the northern Great Plains, the problem of watershed protection is of the greatest magnitude, and surveys and studies are now being undertaken by the newly created Division of Erosion in the Department of the Interior to determine and apply practical remedial measures.

TWO GENERAL CLASSES OF WATERSHEDS

Between these two extremes there are two broad types of watersheds about which there has been much discussion. One type, here called Type A, embraces watersheds located almost entirely south of the Mason and Dixon line and east of the 100th meridian, in the Southeastern and South-Central States, together with scattered areas along the Mississippi River and its principal tributaries and in parts of Texas. In these areas climatic and soil conditions are favorable to the raising of crops by cultivation, and this is the principal agricultural activity.

To some extent agricultural practices in these areas may be different from those used in the Northeastern, Northern, or North Central States. These differences, however, can hardly account for the fact, as stated by the Secretary of Agriculture, in the *Yearbook of Agriculture*, U. S. Department of Agriculture, 1932, pages 349–351, that "some 17,500,000 acres, at least, of formerly cultivated land in this country have been essentially ruined by gullying, and between 4,000,000 and 5,000,000 acres of alluvial land have practically been despoiled by overwash and increased swampiness."

This ruined area represents between 4 and 5 per cent of the total crop land in the United States. There is no question but that the existing condition of the surface is to be ascribed largely to clearing and cultivation. In these areas the problem of watershed protection is acute and relates almost entirely to agriculture by tillage.

The other type of watershed, here called Type B, embraces arid areas in the public-land states west of the 100th meridian, in which conditions are unfavorable to the production of cultivated crops and in which, except in minor areas where the lands are artificially irrigated,

AN ENORMOUS SLIDE ON THE GROS VENTRE RIVER
Which Took Place near Jackson Hole, Wyo., in June 1925

grazing is the dominant land use. A large part of the remaining unreserved, unappropriated public domain lies within such watersheds. Here the vegetation is naturally sparse and climatic conditions are erratic. Overgrazing on such watersheds tends to modify the vegetative types, and if prolonged it impairs the protective covering, thus accelerating natural changes in the land surface. Estimates of the extent to which acceler-

ated changes brought about by overgrazing have destroyed grazing values, changed the regimen of rivers, or interfered with hydraulic works or structures vary widely.

During the white man's occupancy of these areas, land forms have changed, rivers have altered their courses, and the efficiency of hydraulic works and structures has been lessened. In the opinion of many, the changes known to be directly attributable to man's activities are relatively small. Others attribute all changes to man's occupancy. The casual observer does not differentiate between natural changes and artificially accelerated changes. Seeing on the ground, or in pictorial form, evidences of vast topographic changes or silt-burdened rivers and reservoirs, many persons too readily ascribe the causes to the visible activities of man rather than to the forces of nature. Regardless of the cause, a problem of watershed protection is present in these areas. To the extent that the magnitude of this problem is attributable to man it may be in part solved by man; to the extent that it is a problem of natural processes, man's efforts will be of little avail.

ENGINEERING WORKS HELPFUL AND DETRIMENTAL

Human efforts to lessen these changes and minimize the resultant damages in Type B areas have generally consisted in the construction of engineering works or the development and maintenance of a vegetative cover. The extent to which these methods may be economically sound and fulfill the ends sought depends largely upon the character and magnitude of the changes and the underlying reason for their occurrence.

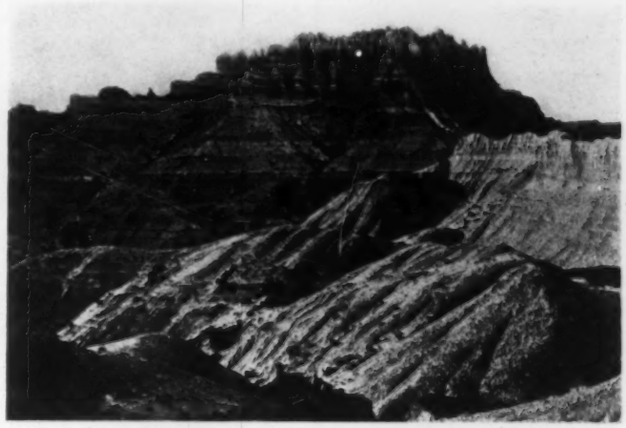
Within reasonable limits, engineering works may be designed to reduce locally the force of water as a transporting agent. Through the construction of reservoirs, it is possible to change the regimen of rivers to such an extent that their transporting power is decreased. Through the construction of diverting structures, blankets, and "check" dams, it is possible to protect locally against change and in some degree balance the working forces as regards scour and fill.

On the other hand, engineering works may have been

NATURAL EROSION AT THE FOOT OF CHURCH BUTTE
Near Granger, Wyo.

so designed or located as to accelerate natural changes. In rare instances the resultant damages may outweigh the accrued advantages. Railroads, highways, bridges, and buildings may encroach on natural channels. Dams may fail, or reservoirs, through desilting processes, may change downstream topography. Drainage systems or irrigation projects may produce unnatural changes. To the extent that these conditions can be remedied by changes in design or location, benefit will result therefrom.

As has been pointed out, cultivation practices have apparently caused much of the widespread devastation of lands in watersheds of Type A, and overgrazing has



A SPUR AT SOUTH END OF SHEEP MOUNTAIN
In the Bad Lands of South Dakota

caused the greater part of the unnatural changes in watersheds of Type B. Engineers may have aggravated the situation locally, but it is believed that the millions of acres of crop lands made available through irrigation and drainage more than outweigh any destructive changes that might conceivably have been brought about through poor design and location of engineering works. On the other hand, proper engineering design and construction, as previously mentioned, aid to some extent in the solution of the problem. Moreover, the problem of eorosion is not wholly one of prevention. As has been shown, a large amount is inevitable, and deposition is the inescapable result. The soils of the best agricultural regions of the country were formed by alluvial deposition of eroded material. The engineer may assist in localizing deposition to the advantage of the land user, and by guidance and control of deposition he may, for example, convert low-lying swamps into pleasant parks or playgrounds or highly valuable agricultural lands.

SOME REMEDIES SUGGESTED

On the watersheds of Type A, man could refrain from cultivation in areas where experience has amply demonstrated that owing to the character of the soil and topography, under existing climatic conditions, disturbances in soil or soil cover bring about unnatural and deleterious changes that destroy or greatly impair the utility of the land. It is desirable, if the condition is to be remedied, that farmers in such areas should be not only trained but assisted in methods of slowing down unnatural changes. Measures that have been suggested to accomplish these aims include terracing, building of inexpensive dams, crop rotation, strip cropping with and without terraces, strip subsoiling, surface cupping, and the use of living dams and soil-holding vines and grasses. The training and assistance necessary to accomplish these objectives constitute a problem for local, state, and Federal agencies and are now being actively carried on in many sections of the country by the Public Works Administration and the Civilian Conservation Corps.

On watersheds of Type B, the benefits received per unit of area are in general materially less than those obtainable from activities on watersheds of Type A.

Except locally, where material changes in surface topography affect hydraulic works and structures or vitally affect human occupancy, remedial measures that may be sound for watersheds of Type A may be economically unsound for watersheds where grazing is the principal activity. For such watersheds protection through range management, to provide maximum utility of the natural vegetation with a minimum of damage to the watershed, seems to be all that can be reasonably accomplished. This again is a land-use problem.

THE YELLOW SLIDE, ANNA CREEK, OREGON
A Tremendous Earth Movement Not Attributable to Man's Activities

Much of the preceding discussion relates to changes that have taken place on farming and grazing lands and to remedial measures proposed for such changes. Separate and apart from the agricultural and engineering aspects, the maintenance and development of naturally forested areas for their timber resources and as a means of watershed protection is fairly well established by law and practice as an American policy. There have been differences of opinion, however, as to both the efficiency and the suitability of forests for the protection of watersheds of all classes. These differences have resulted largely from differences in opinion as to the functions of a forest.

Great emphasis has been placed on the ability of forests to increase water supply, ensure more favorable conditions of flow, conserve rainfall, and promote and protect navigation, the last being stressed particularly in Federal laws. There is a widespread opinion among hydraulic engineers and hydrologists, which seems well supported by statistical evidence, that forests substantially lower stream flow at practically all seasons and at all stages, including flood, minimum, total, and average flow. It seems evident, therefore, that the protective properties of forests which should be stressed are their ability to reduce or retard erosion, conserve soil, and lessen torrential run-off. Forests, however, are not the sole variety of vegetative cover which possesses these properties. Brush, shrubs, and grasses perform similar functions and have a less detrimental effect on annual run-off and summer low-water flow. Various vegetable types have different economic, as well as different protective values. In studies of watershed protection it is therefore necessary to determine the type of cover that will best protect the soil, minimize the water losses, and provide for the most economical use of the watershed and of the water yield. The cover may consist of forests or lesser plant species, depending on soil, topography, climate, and the nature and amount of the water-supply requirements of the dependent region.

SOLUTION INVOLVES MANY AGENCIES

Without question, erosion is a serious problem. It is necessary to realize, however, that in all parts of the country it is a natural process, which can be accelerated by man's activities. The problems of devastation on farm lands are separate and distinct from those of the semi-arid lands of the West. The problem of preventing erosion on lands where a substantially complete cover of trees, brush, or sod can be maintained, is distinct from that on lands where the optimum vegetation consists of scattered individual plants or where no vegetative cover can be established or maintained.

Assistance in the solution of the problem can be rendered by the plant and forest ecologist, the soil technologist, the biologist, the geologist, and the engineer, who can bring to the land user the results of experimental research. The problem will not be completely solved, however, until the husbandman who tills the soil and the user of the land surface acquire through actual experience a knowledge of cause, effect, and remedy, worth far more than anything recondite science can offer.

SMALL LOG DAMS BUILT IN A GULLY TO PREVENT EROSION

Principles of Westchester's Parkway System

A Populous Residential County Contiguous to New York City Provides for Large-Scale Motor Transportation

By JAY DOWNER

MEMBER AMERICAN SOCIETY OF CIVIL ENGINEERS
CHIEF ENGINEER, WESTCHESTER COUNTY PARK COMMISSION, WHITE PLAINS, N.Y.

THERE can be no doubt as to the magnitude of the problem faced by the Westchester County Park Commission in providing proper and adequate highway facilities for the vast numbers of motorists bound to and from New York City. Yet according to Mr. Downer this problem is being solved with outstanding success by means of a system of recreational and express highways. Although the first of the type of parkway which has proved so successful came into being "more by accident than by foresight," a large amount of careful planning and prevision is evidenced in the present system. The basic principles of location and design are here explained in an article originally presented before a meeting of the Metropolitan Section of the Society in January 1933.

RAPID development of the motor vehicle to provide cheap, fast, and safe transportation has placed exacting requirements on the highway and has demanded that it function with a new measure of efficiency. Many long-accepted practices of highway builders have been changed in the last few years, but no aspect of this evolution is more important than that relating to the basic principles of location and right of way. Particularly in metropolitan regions, it is no longer possible to deny that the old routes, through the heart of congested centers, are obsolete. Such roads on a right of way of ordinary width invite promiscuous access and parking, the two primary causes of traffic inefficiency. That the through motorist and the shopper in the local store make a bad combination is now well recognized. Long-distance traffic must be taken care of on a protected expressway, or "freeway," as the new type of highway has been termed by Edward M. Bassett.

ADVANTAGES OF THE "FREEWAY"

As compared with the better-known parkway, which is devoted to passenger car travel, the freeway, although similar in design, has the sole function of providing an artery for the movement of both passenger and commercial traffic. The freeway thus becomes a highly specialized application of the principle of the broad right of way, and depends for its efficiency on three things:

1. Sufficient width of right of way to provide a shielding strip of land on both sides of the paved road, thereby excluding privately owned abutting property from direct contact with the traveled way.
2. Elimination of grade crossings at main intersecting highways.
3. Infrequent spacing of access and exit roadways to reduce friction between entering and departing vehicles and the main traffic streams.

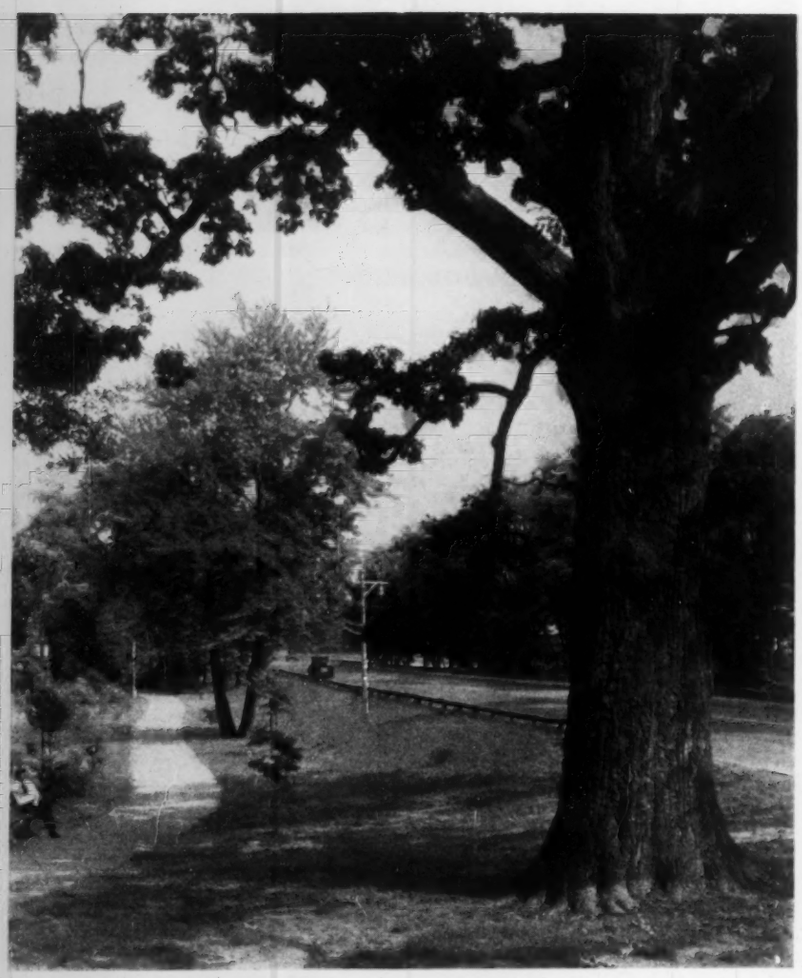
A major advantage of the broad right of way, and one that is economically perhaps more important than traffic capacity, is the enhancement of abutting property values instead of their depreciation,

NEW YORK CENTRAL RAILROAD CROSSING AT MILLWOOD, N.Y., BRONX PARKWAY EXTENSION
Parkways in Westchester County, New York, Are Flanked by Wide Protective Strips

WOODLANDS TAVERN AND GAS STATION
Sawmill River Parkway

which inevitably results along the ordinary main highway. The land in excess of that required for the paved motorway serves to insulate the abutting property from the blight of traffic noise and fumes. To be effective (in urban or suburban territory), a minimum width of 300 ft is desirable, although conditions of topography and the possibility of protective planting sometimes justify less.

In addition to the protection aspects of the broad right of way, the control of frontage which it gives is desirable from the standpoint of esthetics, a feature which the public is beginning to demand, particularly for recreational drives. Roadside disfigurement by signboards,



CROSS COUNTY PARKWAY AT MT. VERNON, N.Y.
Westchester County Parkway System

unsightly filling stations, and many other accretions, which also tend to lower real estate values, is automatically eliminated by controlled frontage. That feature is also of economic importance to the department which operates the highway, for it allows income from the rental of gas and refreshment stations, which when properly designed are satisfactory and necessary appurtenances.

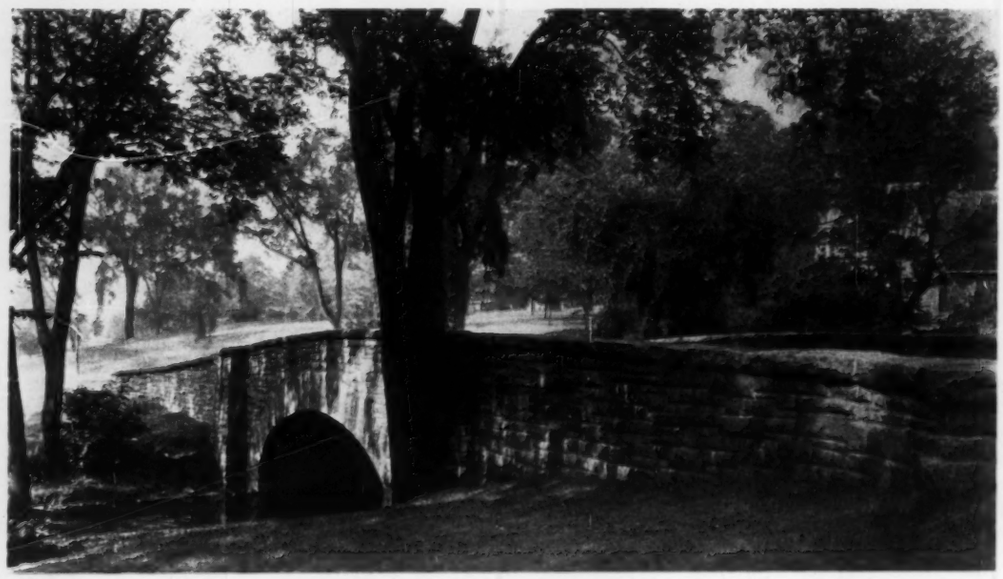
The location of arteries in outlying sections rather than through busy centers obviously permits a greater flexibility in design and alignment as well as in gradient. The necessity for slicing off developed properties, destroying old walls, valuable trees, and other natural features is minimized—a consideration of as much economic as esthetic importance. The worthy objective of fitting the roadway to the natural features of the landscape may be attained by widening and flattening the slopes of cuts and by reducing the fills by curvature.

The added flexibility of the broad right of way also makes it more practicable to eliminate the crossing at grade of principal intersecting streets, which constitutes the greatest menace to safe and uninterrupted traffic flow. At the more important separations, four access drives (the clover leaf) should be provided so as to eliminate left turns on both roadways. At less important separations, two access driveways permit safe ingress and egress. When conditions make bridges for grade-crossing elimination impracticable, entrances and exits may be staggered or the pavement may be widened and safety islands introduced.

Curvature, to permit a reasonable speed, is more important than grade. The general use of the high-speed motor car requires a minimum radius of 750 ft. Also, super-elevation has been commonly applied to curves of less than 2,000 ft in radius. The general matter of easing the roadway alignment to afford proper "riding transition" between curves and tangents is a most vital element of roadway design. It is inseparably tied to a consideration of gradients, up and down; therefore studies for alignment and profile should proceed together. These riding qualities of the roadway affect the ease of driving, and therefore traffic safety.

A coincidental development of the paved four-lane parkway 44 ft wide has been the use of curbs to displace the shoulder and gutter used on the two-lane highway. The curbs, usually 3 in. high, fulfill two functions: they bring surface drainage to the inlets effectively at lower maintenance cost, and they prevent motorists from driving and parking on marginal lands.

In consideration of the various requirements of the modern expressway, the practice of widening the old highway that leads through the center of town is impracticable from every angle. Although such reconstruction may relieve congestion to some extent, the method is at best a palliative and the highway soon becomes congested with a maze of local and through traffic. It is probable that in most cases the cost of acquiring the land for the widening is higher than the total cost of both land and construction for a by-pass on an entirely new and protective right of way. The first highway remains a detriment to local business and real estate; the



BRIDGE OVER THE BRONX RIVER ON THE PARKWAY WHICH TAKES
ITS NAME FROM THAT STREAM

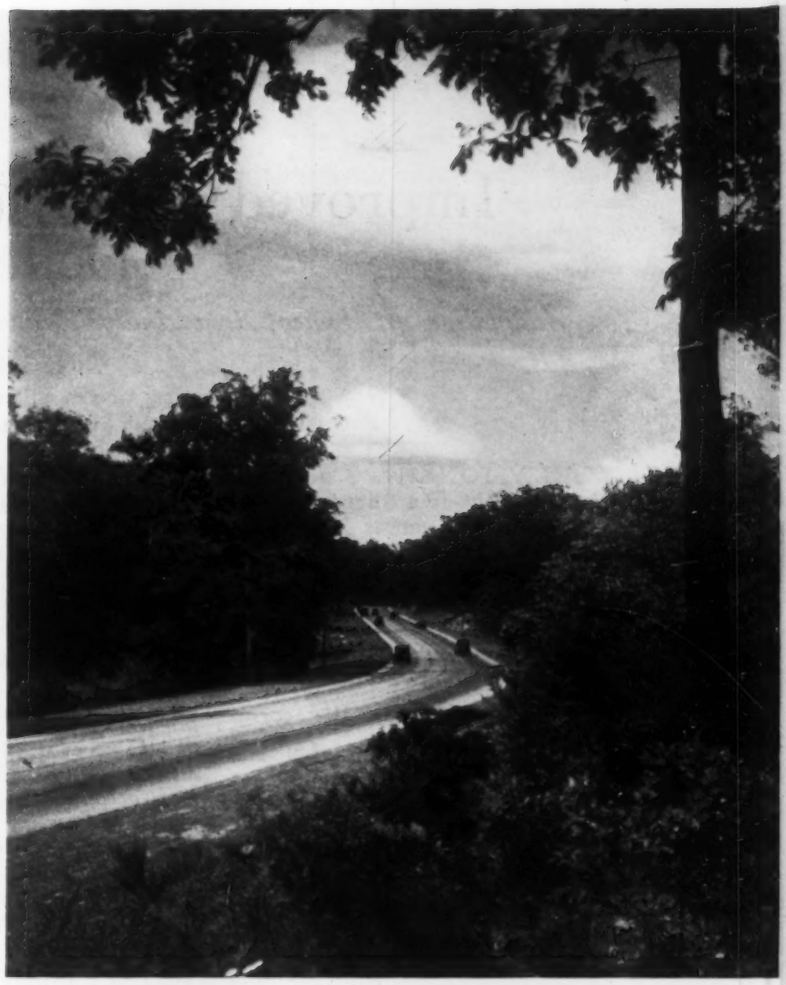
second, in addition to functioning properly as a road, is likely to enhance real estate in the business area it by-passes, and in the new territory it may make accessible.

CHANCE PLAYED A PART

More by accident than by foresight, the pioneer Bronx River Parkway, completed in 1925 by New York City and the County of Westchester jointly, afforded the first convincing demonstration of the soundness of the principle of the by-pass highway in a broad, protected right of way. This development may be traced back some thirty years to a public protest against unsanitary conditions in the Bronx River Valley, which had become cluttered with every conceivable kind of refuse from the city. The clean-up program resulted in the 15-mile parkway drive from the Bronx Zoological Gardens to Kensico Dam, above White Plains, N.Y.

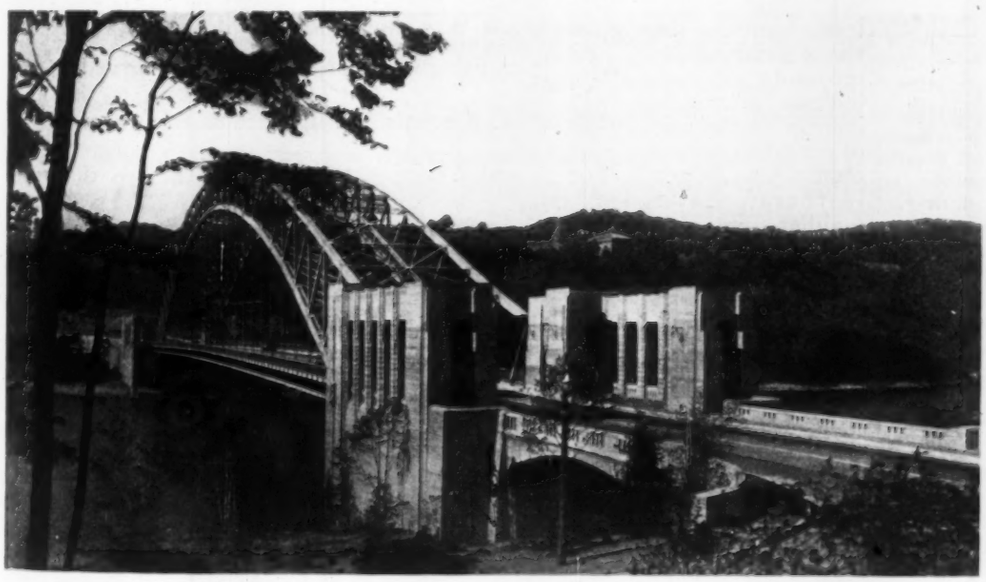
The Westchester County Park System, which is an outgrowth of the earlier project, now includes 160 linear miles of parkway land and 82 miles of completed roadway. Because of its situation adjacent to New York City and the diversity of its natural beauty, Westchester has always been in the main a residential community, feeding a considerable number of its 550,000 people as "commuters" to New York City business houses. At the inception of the Park Commission in 1922, the need for arterial highways between the metropolitan center and the upper part of the state and New England was becoming urgent. The attendant problem of protecting Westchester's residential character led to the broad acceptance of the principle of the protected by-pass highway. The regional plans now projected for northern Westchester include six through-traffic arteries, three of which are to be state highways in broad rights of way, by-passing present and future urban areas.

Of these, the Briarcliff-Crotonville and Peekskill cutoffs, affording relief routes for the bottle necks on the Albany Post Road at Ossining and at Peekskill, were completed in 1933 by the State Highway Department as freeways. The County Park Commission, which acquired the right of way, turned over to the state a strip of land just wide enough for the paved motorway, with the result that the Commission remains the only owner of abutting property.



HUTCHINSON RIVER PARKWAY AT NEW ROCHELLE, N.Y.
Weschester County Parkway System

Since the program was initiated 11 years ago, the total assessed valuation of Westchester's taxable property has more than doubled, that is, it has increased by over one billion dollars. It is believed that the development of parkways and recreation parks is a major cause of this growth. Recent studies of land values in the area affected by the Bronx River Parkway indicate that through increased tax revenue this project has paid not only for its maintenance and operation but also for its entire capital cost. It is particularly notable that the tax rate has been lowered during the period. This economic feature of the broad right of way emphasizes the futility of the old plan for the arterial road. It is a reasonable forecast that the parkway-freeway design is destined to be generally accepted as one solution in many metropolitan regions.



CROTON LAKE BRIDGE ON THE BRONX PARKWAY EXTENSION
A New York State Parkway

Improved Method of Finding Beam Deflections

Adaptation of Moment-Area Analysis Shows Elastic Curve Similar to Railroad Spiral

By Ralph W. Stewart

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MANY methods are available to the structural engineer for relating the moment in a beam to its resulting deflection. One of the earliest was that so popular years ago with the mathematically-minded student, depending on "double integration" of the moment equation. Then came the conception of "moment area," by which many engineers found they could solve the same problems more intelligently. Following this same idea, Mr. Stewart's unique method uses bending-moment diagrams for computing deflections, based on simple properties of the elastic curve of the beam. His equations are in some cases much shorter than those by moment areas. As this new method is easy to grasp, it should become a useful tool.

RELATIONSHIPS between moment-area diagrams and deflection curves have often been demonstrated and need not be discussed here except to mention the fundamental law that the change in direction of the elastic curve between two points on the axis of a bent beam is equal to the area of the $\frac{M}{EI}$ diagram between the corresponding points. From this has been derived the relationship that the slope of the elastic curve at the end of a simple beam is equal to the reaction at the end of the beam obtained by using the $\frac{M}{EI}$ diagram as an imaginary load.

In Fig. 1 is given a diagram, familiar in beam literature, showing a span of constant moment of inertia, with no transverse loads, with a hinge at A and a moment, M, applied at B. From the fundamental law and its corollary, the total curvature, Δ, in Fig. 1 (a), is equal to the total area of the $\frac{M}{EI}$ diagram in Fig. 1 (b); and the angles at A and B of triangle ABC, in Fig. 1 (a), are respectively equal to one-third and two-thirds of Δ. A further point to note is that the uniform increase in the ordinates of the moment diagram indicates a uniform increase in the rate of curvature of the elastic curve, which is therefore the familiar railway transition spiral.

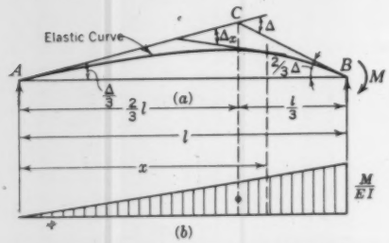

Fig. 1. Deflection Curve for a Beam with a Moment at One End

If a equals the rate of slope of the moment diagram, the ordinate at any distance, x, from the left end is ax, and the area of the diagram for the distance x is $\frac{1}{2}ax^2$. The corresponding value for Δ_x is also $\frac{1}{2}ax^2$, in which a represents the rate of increase of curvature. It may be noted that these equations are also analogous to $h = \frac{1}{2}gt^2$, which gives the height that a falling body traverses in a given time, t, and are in the form which expresses the integral of uniform increase in a quantity.

Properties of Deflected Beams

Some of the important properties of Fig. 1 are as follows:

1. The angle Δ (in circular measure) is numerically equal to the area of the $\frac{M}{EI}$ diagram and is located opposite the center of gravity of that diagram.

2. The angles at A and B, and the angle Δ at C, are in the ratio of 1:2:3. This follows since, using the $\frac{M}{EI}$ diagram as a load, the reaction at A is one-half that at B and the total load, or Δ, is the sum of the reactions. For comparison, reference may be made to the derivation of these same angle relationships in works on railway spirals.

3. In all cases within the limits to which beams deflect in buildings and bridges, the altitude of the triangle in Fig. 1 (a) will be so small that the angles, their tangents, and their sines may be taken as equal. Consequently the sides of the triangle as well as its angles will follow the ratio of 1:2:3.

4. Furthermore, for all cases within and far beyond the scope of spirals involved in structural beam deflections, the ordinates to the curve from the tangent AC, Fig. 1 (a), vary as the cube of the distance from A.

Referring to Fig. 2, the simplest application of the method proposed for analyzing beam deflections is a cantilever of constant cross section with a single load at the end. Draw the "one, two, three" triangle ACB, placing C under the center of gravity of the moment diagram. It is now seen that the deflection, d, equals $\Delta\left(\frac{2}{3}l\right)$; or, using the chord of the elastic curve and the angle at A, d equals $\frac{2}{3}\Delta(l)$, which is the same. Since $M = pl$, and Δ is equal to the area of the $\frac{M}{EI}$ diagram, $\Delta = \frac{Pl^2}{2EI}$ and $d = \frac{Pl^3}{3EI}$. It is noted that the equations for this case are identical with those in the well-known moment-area solution, but the concept is the product of a slope and a distance rather than the moment of a quantity times its lever arm.

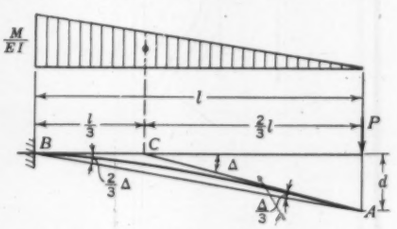

Fig. 2. Deflection Curve for a Cantilever Beam

As an illustration in which the equation is not the same as that involved in the moment-area method, Fig. 3 shows a deflected column of height h, for which a solution is given by

S. C. Jemian, Assoc. M. Am. Soc. C.E., on page 548 of the October 1933 issue. It is desired to obtain the bending moment, M, induced by distortion into a symmetrical reversed curve by shrinkage of the girder deflecting the top of the column a distance d.

From the figure, $d = \Delta(2/3\,h)$. But Δ = area of one $\frac{M}{EI}$ triangle, $= \frac{M}{EI} \cdot \frac{h}{4}$. Therefore $M = \frac{6\,EId}{h^2}$, which will be found to agree with Mr. Jemian's analysis, his Δl and my d being identical.

Another solution of this problem by the ordinary moment-area method is given by L. E. Grinter, Assoc. M. Am. Soc. C.E., on page 7 of the January 1933 PROCEEDINGS. Both these solutions involve longer equations and more computations than the one given here.

The properties of the elastic curve described simplify the work of determining the alignment of that curve for its entire length even when its direction of curvature reverses by passing through points of contraflexure.

In Fig. 4, the angle points B, C, D, and E of the beam AF are under the centers of gravity of their respective moment triangles, and the values of the angles Δ_1 to Δ_4 are equal to the $\frac{M}{EI}$ triangle areas. This enables the framework of tangents to the elastic curve to be immediately drawn. All desired intermediate points along the

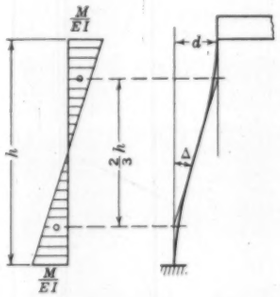

FIG. 3. DEFLECTION CURVE FOR A FIXED COLUMN WITH HORIZONTAL DEFLECTION

branches of the curve may be determined from Property 4 listed for Fig. 1.

OTHER BEAMS AND LOADINGS CONSIDERED AND ILLUSTRATIONS GIVEN

This method of solution may be applied with equal facility to beams with uniform loads in which the ordinates of the M diagram terminate along a parabola instead of along a straight line. The constants, however, are modified as follows.

For a uniformly-loaded cantilever beam, the triangle formed by the tangents and chord of the elastic curve is a 1:3:4 diagram (instead of a 1:2:3) and the ordinates to the elastic curve from its longer tangent vary as the fourth power of the distances from the end of the curve. The angle point is opposite the center of gravity of the $\frac{M}{EI}$ diagram and the values of the Δ angles are numerically equal to the areas of the diagrams in this and all other cases.

For a uniformly-loaded simple beam, the triangle formed by the tangents and chord of each half of the elastic curve is a 3:5:8 diagram. In this case the elastic curve is treated as two units, one on each side of the center of the beam. The ordinates to this curve also vary as the fourth power of the distance from the end of the longer tangent.

In a simple beam with an eccentric concentrated load, the direction of none of the sides of the 1:2:3 diagrams is immediately known. It is known, however, that the elastic curve is parallel to the unsprung beam opposite

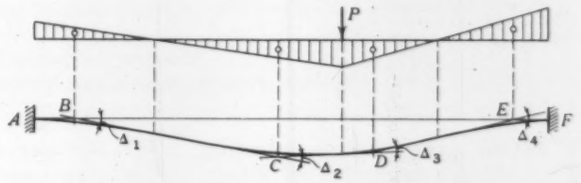

FIG. 4. DEFLECTION CURVE FOR A BEAM FIXED AT BOTH ENDS

the point of zero shear when the moment diagram is used as an imaginary load. By cutting the moment diagram at this point, the 1:2:3 diagram for one side of the cut may be drawn. This gives a sufficient start to enable the entire curve to be completed by application of the properties listed for Fig. 1.

Study of elastic curves by this method can be extended to beams of variable moment of inertia in the following way. After the $\frac{M}{EI}$ diagram is drawn, the angle Δ is given a value equal to the area of this diagram and placed opposite its center of gravity. If the direction of either tangent to the elastic curve or its chord is known or can be determined, the tangent and chord diagram for the elastic curve is immediately known. This is useful in deriving fixed end moments, carry-over factors, and stiffness factors for non-uniform beams to use in the "end moment distribution method" of analyzing continuous frames.

For the trapezoidal moment diagram of an unloaded span in continuous beams, the non-parallel lines of the trapezoid can be produced to form a triangle. The 1:2:3 diagram and elastic curve for this triangle can then be determined, and finally the part for the trapezoid can be oriented with reference to the end slopes of the beam.

ELASTIC CURVE A CUBIC PARABOLA

In beam literature the cubic parabola is used as the equation of the elastic curve produced by a concentrated load. For convenience, since Δ is small, let it be assumed as equal to its tangent; then $\tan \Delta = {}^1/_2\, ax^2$. But $\tan\Delta$ is the first derivative of the ordinate y, expressed as a function of the abscissa x. Integrating, $y = {}^1/_6\, ax^3$, which is the equation of a cubic parabola. This shows that for the condition involved in ordinary beams (that is, the length along the axis of the deflected beam is taken as equal to the length along the unsprung beam), the two curves are the same. The railway transition spiral, however, is more satisfactory to use in analysis as it immediately discloses the 1:2:3 relationship and other properties which are not clearly expressed by the cubic parabola.

In general, therefore, the equation of the railway transition spiral perfectly expresses the law of the elastic curve for beams of constant cross section and linear variation of bending moment. It enables deflection problems for such beams to be reduced to a very simple form of geometry. The geometrical treatment of the elastic curve can be readily extended to beams with uniform loads and to other cases of non-linear variation of $\frac{M}{EI}$ ordinates. In some instances this clarifies and shortens the analysis as compared to methods heretofore published.

Soundness Tests for Sewage Filter Media

Accelerated Sodium Sulfate Test Compared with Freezing and Thawing Test

By H. G. Payrow

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In climates which subject the slag or stone used in sewage trickling filters to alternate freezing and thawing, it is important that these materials be as durable as possible. Soft or easily disintegrated media not only tend to clog the filter but necessitate frequent replacements. A committee of the Sanitary Engineering Division has devoted much effort to perfecting an accelerated test that can be applied to prospective materials to determine their suitability for use as filtering media. The crystallization of sodium sulfate solutions absorbed by the media under test exerts a force analogous to that caused by the freezing of water similarly absorbed. Although the former test may be quicker and more severe, Professor Payrow considers that the freezing and thawing apparatus used by him permits a simpler and probably more accurate determination. He here compares the results obtained by applying the two tests to the same materials and gives reasons for preferring the latter method.

FROM experience in operating existing sewage trickling filters, it has been concluded that the filtering media should be sound, hard, of uniform size, clean, free from dust or fine material and should have no tendency to reduce in size by disintegration. In trickling sewage filters the tendency of the media to disintegrate is accelerated by the possible condition of alternate freezing and thawing. This disintegration may take place in three ways: by a splitting of the material along laminations; by an internal expansion, in which the specimen is ruptured so that it is reduced to small pieces; and by crumbling.

In view of these conclusions, soundness tests were made at Lehigh University on several samples of limestone and slag to compare the ability of these two materials to resist disintegration and to compare the effectiveness of the sodium sulfate test with that of the freezing and thawing test.

According to the theory on which the accelerated soundness test with sodium sulfate is based, it is assumed that during immersion of the specimens in a solution of uniform strength (Na_2SO_4) a sufficient quantity of the solution is absorbed in the pores of the material to hydrate or crystallize and exert a disruptive force similar to the effect of the expansion of freezing water. Heating the specimens in an oven at about 100 C to dehydrate the salt in the pores prepares them for further absorption and crystallization when they are again immersed.

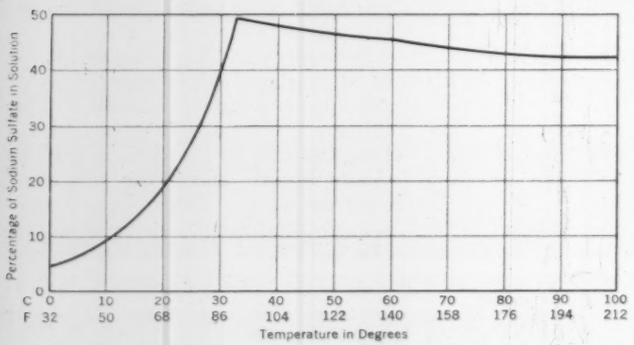


Fig. 1. Solubility-Temperature Curve for Sodium Sulfate Solutions

Since the anhydrous salt (Na_2SO_4) is used in preparing the solution, it is hydrated to the highest form, the decahydrate ($Na_2SO_4.10H_2O$), which is stable below 32.49 C and at such temperatures produces the maximum destructive force.

As shown in Fig. 1, the solubility-temperature curve is of interest because it indicates that in a change of temperature from 20 to 30 C, a variation which could be produced in any room or laboratory, the strength of the solution changes from about 20 to about 40 per cent. This means that there should be an excess of crystals present at all times. As there is no definite procedure for this test at present, the soundness test under a constant temperature (25 C) would tend toward standardization, although it would reduce the severity of the test, as it abrogates the growth of crystals due to temperature changes. It is obvious that a variation in temperature may affect the results of the test considerably.

For this investigation four samples of limestone and two of blast-furnace slag were selected. Of the former, two were from widely separated quarries in the West and two from quarries in eastern Pennsylvania. The slags were from two different points in eastern Pennsylvania.

Sample W-A was gray limestone inclined to be somewhat laminated; sample M-B was light gray limestone containing short dark streaks distributed throughout each piece; and samples A-C and N-D were gray dolomite limestone of homogeneous structure. The samples of commercial slag had been reclaimed from abandoned slag dumps, processed, and placed on the market for various purposes, including sewage filter media. In general appearance both were of a gray color with rather rough surfaces but no cleavage planes. Slag sample C-E had a very honeycombed appearance throughout, but sample G-F consisted nearly 50 per cent of pieces resembling dolomite limestone.

After the specimens had been dried, all loose fragments were removed from them and they were placed in glass jars containing a saturated solution of anhydrous sodium sulfate (Na_2SO_4), which was prepared by adding 400 g per liter of hot water. The specimens were then stored in a room having an average temperature of 22.3 C and 100 per cent humidity. The maximum temperature variation, as indicated by a continuous recording thermometer, was 2.8 C. The specimens were subjected to a treatment of 20 cycles, each cycle consisting of 19 hr of immersion in the sodium sulfate solution, 4 hr of drying or dehydrating in a previously heated oven at an average temperature of 120.9 C, and 1 hr of cooling, including time for inspection.

A comparative soundness test by the method of freezing and thawing was conducted on samples of the same

type as those used in the sodium sulfate test. The samples were selected as in the preceding tests. After drying, they were placed in separate metal containers about 18 in. deep and were entirely covered with water. The containers were then put in a refrigeration compartment and subjected to 100 cycles of freezing and thawing. A complete cycle of freezing and thawing was obtained every 24 hr.

In order to compare the samples and to formulate a measure of their durability, the following procedure was adopted: (1) an individual specimen which ruptured into three or more pieces and which from all evidence appeared to be a complete failure, was weighed and counted as loss; (2) all chips, spalls, flakes, or debris were weighed and counted as additional loss; and (3) the final rating, the sodium sulfate or the freezing and thawing characteristic, was found by subtracting from 100 the percentage of the total loss. The results obtained were as shown in Table I.

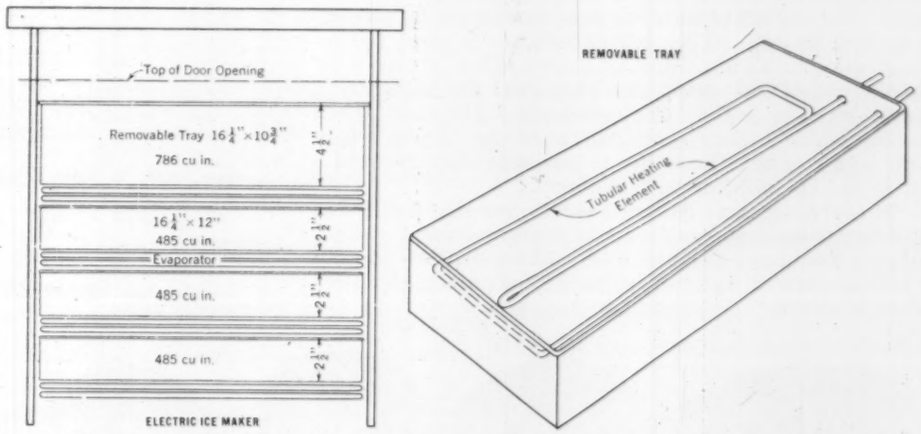


FIG. 2. STANDARD ELECTRIC ICE-MAKER ADAPTED TO FREEZING AND THAWING SOUNDNESS TEST

Of the four limestone materials, samples W-A and M-B, Table I, unquestionably must be rejected for filter media, as indicated by their low showing in both tests. Samples A-C and N-D, dolomite limestone, are however very acceptable material for that purpose. Of the slag samples, C-E and G-F, the former might be questionable, but the latter is very acceptable. Contrary opinion notwithstanding, it is evident that slags do differ in their reaction to soundness tests—a fact I have repeatedly checked. From the log of the sodium sulfate test, it is concluded that effective disintegration occurs early in some instances. In the rejected limestone samples, W-A and M-B, the first evidence of disintegration occurred at the fourth cycle, whereas in the acceptable slag samples, C-E and G-F, disintegration did not develop until the fourteenth and eighteenth cycles, respectively. It may be concluded from these facts that 20 cycles of sodium sulfate are probably more than sufficient as a soundness test. Either 20 such cycles or 100 cycles of freezing and thawing is an effective test of the soundness of sewage-filter media.

From the results of these tests there is an indication that the sodium sulfate test is somewhat more severe than freezing and thawing. This is further supported by the consistently smaller uniformity coefficient of the debris resulting from the sodium sulfate test, as shown in Table II. It is evident that there is a certain technique required for standardization of this test, which if not followed may produce a wide variation in results for similar samples. In these tests the procedure outlined in a manual being prepared by the Sanitary Engineering Division's Committee on Filtering Materials, of which William E. Stanley, Assoc. M. Am. Soc. C.E., is chairman, was followed. The use of this recommended procedure will do much to standardize the technique of the test. The freezing and thawing test is comparatively simple and requires no special technique—a decided advantage.

FREEZING AND THAWING TEST PREFERRED

After considerable laboratory experience with both tests, it is concluded that the freezing and thawing soundness test is not only conclusive and closest to actual conditions but the most convenient and probably the most economical for routine testing purposes. The time required for it has been a disadvantage, but can be reduced by two-thirds.

TABLE I. FILTER MEDIA CHARACTERISTICS AS DETERMINED BY COMPARATIVE TESTS

Item	Sodium Sulfate Soundness Test						Freezing and Thawing Soundness Test					
	Limestone				Slag		Limestone				Slag	
	W-A	M-B	A-C	N-D	C-E	G-F	W-A	M-B	A-C	N-D	C-E	G-F
Weight of sample, in grams	4,763.00	4,731.00	1,298.80	1,193.60	6,216.00	7,077.00	1,785.00	1,729.00	6,540.00	8,350.00	11,362.00	11,735.00
Number of pieces in sample	22	20	4	4	20	20	10	10	16	24	25	25
Average weight per piece, in grams	216.50	236.50	324.70	298.40	310.80	353.80	178.50	172.90	408.00	348.00	440.00	469.00
Average volume per piece, in cubic centimeters	77.20	96.70	113.80	105.80	133.30	[illegible].00	63.50	70.4	143.00	123.00	188.00	186.00
Specific gravity	2.81	2.45	2.85	2.82	2.33	[illegible].52	2.81	2.45	2.85	2.82	2.33	2.52
Absorption, in percentage	1.62	3.01	0.19	0.21	5.[illegible]	2.12	1.62	3.01	0.19	0.21	5.61	2.12
Sodium sulfate characteristic	66.80	18.50	100.00*	100.00*	86.50	97.10						
Freezing and thawing characteristic							36.00	55.80	99.80	94.70	93.10	99.78

* Very slight disintegration.

It is proposed that a commercial electric ice freezer cabinet be adapted for use in this test. The sketches shown in Fig. 2 indicate an easily accomplished, practical arrangement of the cabinet section of such a freezer. The trays are kept as shallow as possible to accelerate the freezing process. When the pans rest on the evaporator surface, nearly all the heat transfer is through their bottoms to the evaporator. A heating element is shown placed in the middle of each pan to reduce the thawing time and to eliminate the undue heating of the evaporator. The control of the cycle can be arranged by an electric time switch. This will automatically start the refrigerating unit for a definite number of hours, turn it off at the end of the period, and then start the heater for a sufficient time to thaw the specimens. The time switch is adjustable to any combination of time during a definite time cycle. Probably a complete time cycle of 8 hr would be sufficient as a maximum.

This arrangement, designed for the freezing and thawing soundness test, has the merit of compactness, cleanliness, a minimum of labor, and continuousness. A 100-cycle soundness test can be completed in slightly more than a month.

TABLE II. COMPARATIVE SIEVE ANALYSIS OF DEBRIS RESULTING FROM TWO METHODS OF TESTING FILTER MEDIA

Percentages Passing Screens of Various Sizes After the Sodium Sulfate Test and the Freezing and Thawing Test

Size of Screen	Sodium Sulfate				Freezing and Thawing			
	Limestone		Slag		Limestone		Slag	
	W-A	M-B	C-E	G-F	W-A	M-B	C-E	G-F
No. 100	0.75	1.92	0.11	27.7	0.42	1.39	7.30	27.0
No. 48	1.47	2.75	0.17	42.4	0.62	2.46	12.80	42.2
No. 28	2.24	3.82	0.24	52.5	1.15	4.30	23.60	58.2
No. 14	3.34	5.32	0.37	65.1	2.71	7.95	46.10	74.0
No. 8	5.00	7.86	0.55	71.9	6.11	14.00	68.90	88.0
No. 4	7.75	10.22	0.90	75.9	14.95	24.10	85.90	98.0
2/8 in.	13.45	19.30	1.71	78.4	30.10	43.80	100.00	100.0
3/4 in.	28.20	38.00	6.85	100.0	61.50	85.70	....	....
1 in.	....	....	....	....	100.00	100.00	....	....
1 1/2 in.	87.50	87.10	31.25	....	....	....	....	....
2 in.	100.00	100.00	100.00	....	....	....	....	....
Total, in grams	1,587.60	3,844.70	839.50	20.8	373.10	484.90	238.0*	26.0
Effective size	0.26	0.17	0.85	...	0.13	0.06	0.01	...
Uniformity coefficient	4.43	6.68	2.01	...	5.41	8.24	8.64	...

* Two large pieces failed by splitting in halves but were still too large to be considered as debris.

TYPICAL SLAG SAMPLES BEFORE TESTING
Left, Three Samples Designated C-E; Right, Three Samples Designated G-F

ENGINEERS' NOTEBOOK

From everyday experience engineers gather a store of knowledge on which they depend for growth as individuals and as a profession. This department, designed to contain practical or ingenious suggestions from engineers both young and old, should prove helpful in the solution of many troublesome problems.

A Graphic Method of Designing Reinforced Concrete Slabs

By HARRY HORELICK
PATERSON, N.J.

IT is a well-known fact that in cases where three or more variables are mutually interdependent, the parallel coordinate system, or alignment chart, may be used very advantageously to represent this interdependence. It therefore lends itself admirably to the design of reinforced concrete slabs. It is neat, concise, and permits of easy interpolation because of the fact that in most cases the values of the several variables are plotted on straight lines.

NOMOGRAM CONSTRUCTED FOR COMMONLY ACCEPTED RATIO OF MODULI OF ELASTICITY

Construction of this nomogram is based on the most commonly accepted value of the ratio of the respective moduli of elasticity of steel and concrete, that is, $E_s/E_c = 15$. Neither this value, nor the conventional j and k appear directly in the nomogram but they are all involved indirectly in the line marked P (j and k being both dependent upon E_s/E_c). The function represented by the line P is empirical and has been proved by numerous tests to render solutions close enough for all practical purposes.

Although in most cases the bending moment governs the design of the slab, quite often a case presents itself in which shear governs; and sometimes bond controls the depth of the slab. To take care of shear, the line R_s is provided. It shows directly the maximum reaction the slab will safely take in shear. For the consideration of bond, the line marked C is provided. A straight line connecting the size of rod and spacing used will intersect the line C and indicate a value which I choose to call the "bond coefficient." If C is greater than 1, then shear controls the design and the maximum allowable reaction on the slab is equal to the value read on R_s. If however C is less than 1, then bond controls and the maximum allowable reaction on the slab in this case is $R_b = CR_s$. It should be noted that C is different for round and square rods of the same nominal size.

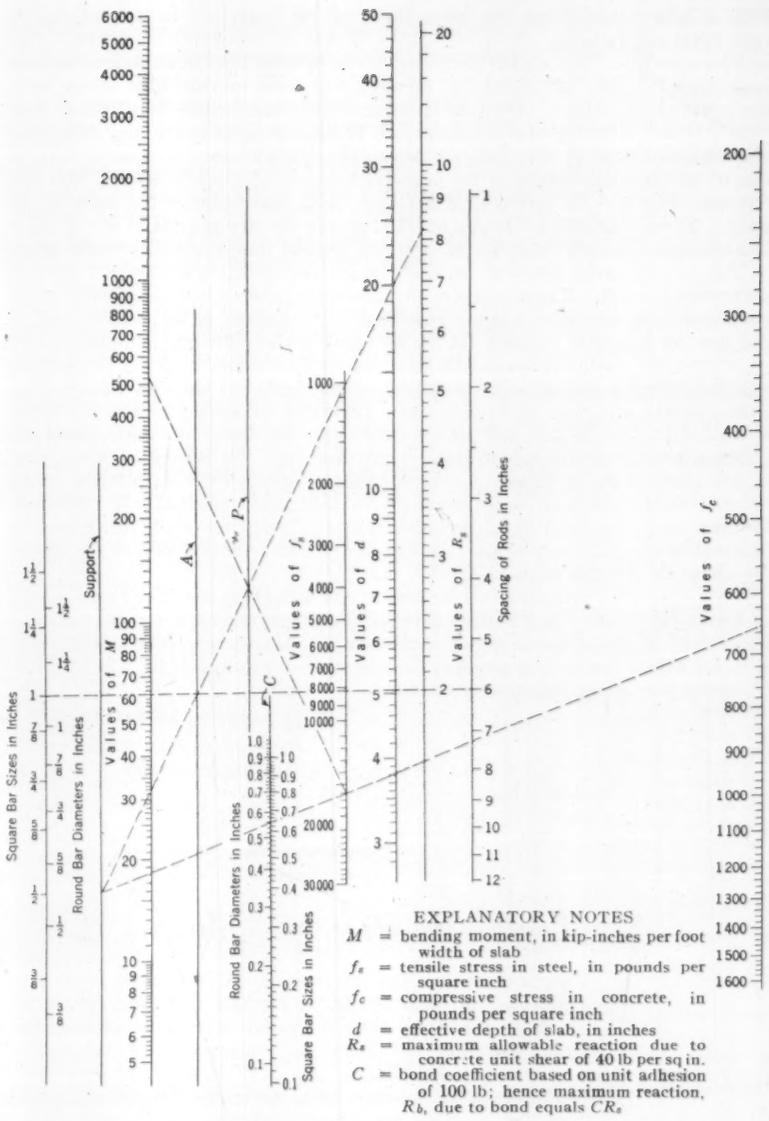

Square Bar Sizes in Inches
Round Bar Diameters in Inches
Values of M
Support
A
P
C
Values of f_s
Values of d
Values of R_s
Spacing of Rods in Inches
Values of f_c
Round Bar Diameters in Inches
Square Bar Sizes in Inches
EXPLANATORY NOTES
M = bending moment, in kip-inches per foot width of slab
f_s = tensile stress in steel, in pounds per square inch
f_c = compressive stress in concrete, in pounds per square inch
d = effective depth of slab, in inches
R_s = maximum allowable reaction due to concrete unit shear of 40 lb per sq in.
C = bond coefficient based on unit adhesion of 100 lb; hence maximum reaction, R_b, due to bond equals CR_s

FIG. I. NOMOGRAM FOR DESIGN OF REINFORCED CONCRETE SLABS

The example shown on the nomogram is the solution of a problem which is here followed through in detail. In this problem the following values are given: M = 530 kip inches, and R = 8 kips.

The problem is to design the most economical slab, that is, f_s = 16,000 lb per sq in. and f_c = 650 lb per sq in. To solve:

1. Join 650 on f_c with 16,000 on f_s and mark the point on the line called "support."
2. Join 530 on M with 16,000 on f_s and mark the point on P.
3. Join the point marked on the support with the point marked on P and read d = 20 and R_s = 8.3 simultaneously. Also mark the point on A.
4. Join the desired size of rods (1-in. square rods in this case) with the point marked on A and read a spacing of 6 in. on centers. Also notice that C is greater than 1; hence R_s controls the maximum allowable reaction.

It can be seen that whatever the combination of knowns and unknowns in the problem, an order of operations may be chosen that will yield the results sought. In this connection the following general rule is to be observed. In order to be simultaneously satisfactory as solutions of a problem, the values of the variables of each of the following groups must lie on a straight line.

Group 1: f_s, f_c, support
Group 2: M, P, f_s
Group 3: size of rod, A, spacing
Group 4: support, A, P, d, R_s

This straight-line relationship makes it possible to determine any unknown or unknowns in any group if two of them are known or, what is the same thing, assumed. The order in which these groups are to be attacked will depend on the information at hand or on the assumptions one is willing to make in connection with the problem to be solved.

Our Readers Say—

In Comment on Papers, Society Affairs, and Related Professional Interests

Full Canalization of the Illinois River

DEAR SIR: In his excellent paper, "Sewage Disposal by Way of the Illinois River," in the September issue, Mr. Pearse has touched on some of the more significant effects which changes in pollution and lake-water diversion have had on sanitary conditions in the river. He also mentions the possible effects of the very recent full canalization of the river, which may have important consequences with respect to the sanitary condition of the river before complete sewage treatment is instituted in Chicago.

A basis for estimating roughly what these consequences may be is afforded by the results of two comprehensive laboratory surveys of the river. One was made by the U. S. Public Health Service in 1921–1922; the other, by the laboratories of the Sanitary District of Chicago during the period from 1926 to the present time. The results of these two surveys have shown remarkable agreement in many respects, notably as regards the observed rates of oxidation and re-aeration in the river. From data on yearly averages collected by the staff of the Sanitary District of Chicago during the period 1926–1931, inclusive, I have estimated that in the 106-mile stretch of river extending from Joliet to Chillicothe, the total amount of dissolved oxygen absorbed from the river by oxidation was roughly 800,000 lb daily, of which about 250,000 lb was absorbed by the bottom sludge deposits. The total amount

of oxygen absorbed by the stream through atmospheric re-aeration was slightly in excess of 1,100,000 lb, or 2.7 lb per 1,000 sq ft of water surface daily, on the basis of the water area determined by the Chicago Board of Engineering Review. This latter amount represents about the maximum rate of re-aeration, since it was observed at almost 100 per cent oxygen depletion in the river. Under summer conditions (from June to September) the total dissolved oxygen absorbed by oxidation was 950,000 lb daily, of which 300,000 lb represented the oxygen demand by sludge deposits. The total re-aeration was about the same as previously noted. These estimates are subject to possible revision, but will serve for illustration.

With full canalization it is doubtful whether a maximum re-aeration rate of 2.7 lb per 1,000 sq ft per day can be maintained, with the increased pool depths and slower velocities of flow then prevailing. If this rate should drop to 2 lb or less, the total amount of re-aeration above Chillicothe would hardly serve to balance the total amount of oxygen absorbed from the river in this stretch, leaving no reserve to maintain aquatic life or to take care of the residual bio-chemical oxygen demand. With the slower pool velocities, sludge deposition may increase above Peru, and conditions in this section of the river are likely to become more critical than they have been during the past few years. However, they may improve below Peru unless the zone of septic conditions should be extended through the influence of increased sludge deposits upstream.

Judging from the effects of full canalization in other highly polluted rivers, such as the Ohio, this measure of improvement in navigation in the Illinois River probably will increase, rather than lessen, some of the difficulties to be overcome in restoring the river to a good sanitary condition, particularly in the 70 or 80-mile stretch immediately below Lockport. This situation should be relieved gradually as sewage treatment progresses in Chicago, although the benefit to be derived from a given degree of treatment probably will be measurably less in the extreme upper river than would be expected on the basis of conditions existing prior to full canalization.

H. W. STREETER, M. Am. Soc. C.E.
Sanitary Engineer, U. S. Public Health Service

Cincinnati, Ohio
December 15, 1933

Is Triangulation Essential in City Surveys?

TO THE EDITOR: The article, "City Surveys—Past, Present, and Future," by George D. Whitmore, in the August number, gives the impression that city surveys cannot be made accurately without the use of triangulation. Many cities have made accurate city maps by precise traverses without triangulation control.

No one can minimize the value of triangulation for the control of topographic mapping of large areas, such as is executed by the U.S. Coast and Geodetic Survey and the U.S. Geological Survey. The ease with which directions and distances can be obtained from a coordinate system, whether it be rectangular or geodetic, is also apparent. However, is triangulation absolutely essential in city surveys?

It is generally conceded that the principal objective in compiling a so-called "city map," is to locate and monument street lines accurately and to indicate by precise and accurate dimensions private property lines, so that a competent surveyor will be able to locate these lines on the ground. This can be accomplished by a network of precise traverses. A random line is first run along the streets, and all available monuments, fence lines, and similar features are located. It is then necessary to make a very careful study of all recorded maps, showing land subdivisions in lots and blocks. Occasionally a search of deeds may also be required. The recorded data frequently conflict with the measurements obtained in the field. This is to be expected, as the land may have had very little value at the time the maps were recorded. Therefore the old surveys would not have a high degree of accuracy. From the available data on record an adjustment must be made to conform to the precise field measurements. This is far more important than the adjustment of the traverses to a triangulation scheme.

It is seldom necessary to run random lines in all streets, as some are calculated and monumented from random lines in adjoining streets. After the traverse circuits and the individual blocks have been properly adjusted, it is possible to establish and monument street lines from the precise random lines, and to fix accurately the dimensions of the property lines, if the block is divided into lots.

The city map of Syracuse, N.Y., was made by the method just outlined. Begun in the center of the city in 1895, it was continuously extended until at the present time it consists of about 700 atlas sheets 20 by 22 in. in size and drawn to a scale of 1 in. to 40 ft. The bearings of the streets are referred to an approximate true meridian and are expressed to the nearest 10 sec, which is sufficiently accurate for the average distance between monuments. No attempt was made to introduce corrections in street bearings for convergence of meridians, as this would introduce unwarranted corrections in some blocks. Distances are shown to the nearest 0.01 ft, a precision seldom obtained in the usual field measurement by the average surveyor of city property. I was engaged on this work for a period of several years. Although the adjustment of the maps on record to the precise field measurements has at times been questioned, no serious complaints have been made concerning the accuracy of the positions of the monuments as shown on the city atlas maps.

Although this method of city surveying would not give the distance and bearing between two points several miles apart with the ease and accuracy obtainable by triangulation, such long distances are seldom required in surveys of city property, for which the city map is primarily intended.

S. D. SARASON, M. Am. Soc. C.E.
Professor of Civil Engineering
Syracuse University

Syracuse, N.Y.
December 13, 1933

Traffic By-Pass of Value on Hills

TO THE EDITOR: The letter by A. W. Robertson in the December issue, on "Slow Traffic By-Pass for Two-Lane Highways," is excellent, especially from the point of view of accident prevention. However, Mr. Robertson's suggestion for the construction of an additional one-lane section of road every two miles on two-lane highways does not seem warranted for any road unless a third lane is needed for its entire length. On a level stretch of road, for instance, most trucks and buses can travel as fast as the average pleasure vehicle.

On long, winding hills a by-pass would accelerate traffic and lessen the chances of accident. At the present time such a by-pass is being constructed by the Pennsylvania Department of Highways on the New Cumberland Hill, in York County, just outside of Harrisburg. The reaction of the traveling public to this improvement will no doubt be followed with keen interest by various state highway departments.

H. D. CAMPBELL, Assoc. M. Am. Soc. C.E.

Harrisburg, Pa.
January 2, 1934

Shop Welding Structural Steel of Skyride

TO THE EDITOR: Mr. Grove's article on the "Design of 'Skyway' and Observation Towers," in the September issue, gives a very complete description of the project as a whole, so my discussion will enlarge on the structural steel aspects of the project and describe the method of shop welding, which was the outstanding fabrication feature. Because of the importance of the welding, tests were made on the various shop-welding operations to determine the type of electrode most suitable for our equipment.

These tests showed that welds were stronger than the standard of the American Welding Society and were uniformly consistent.

In addition to normal compression, the main tower columns are subject to wind uplift, and the combination of welding and riveting, shown in Fig. 1, simplified the detail work on the column base. The main column section consists of three I-beams, the two outside beams of the lower section being 20-in. 150-lb I-beams and the web beam a 15-in. 95-lb I-beam. The three beams were assembled and tack-welded every 10 ft and were then placed in a cradle, which provided for 360-deg rotation. The shop welding was done by means of an automatic welded carriage, having a slow speed for welding and a fast speed for skipping, thus giving any desired spacing.

It was found that by using the automatic equipment, the process of welding did not delay the other shop operations. Therefore the welded column section can be used economically from the standpoint of shop delivery.

Panel points are approximately 25 ft apart vertically. Although the main column section is shop welded, the details are riveted. After the decision to field rivet the work was made, it became necessary to drill holes for the column splices. While the column section was under the multiple drill, very little additional work was required to drill the few extra holes for the batten plates.

After the columns were completely welded and all the details were riveted, the sections were assembled and lined in both directions, and the field holes reamed and match-marked. This shop assemblage facilitated the field erection and resulted in very accurate field work.

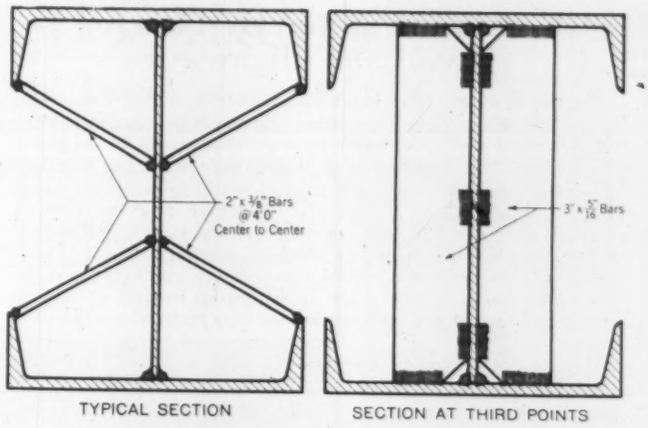


FIG. 2. WELDED STIFFENERS FOR MAIN TOWER BRACING

Machine Welds Placed at Rate of 6 In. per Min and Skips Between Welds Effected at Rate of 40 Ft per Min

The main diagonal tower-bracing members consist of two channels and a plate forming an H-section with the channel flanges turned in, as shown in Fig. 2. Diagonal bar stiffeners connecting the channel flanges to the web plate were welded. These bars were introduced to keep the web in line and, in a measure, to supplant the rolled fillets on a normal H or I-section. At the third points bar stiffeners were introduced to strengthen the web, to connect the channels definitely to the web, and to prevent twisting of the finished member.

These members were welded on an automatic welding machine, which is equipped with two welding heads and welds both sides of the plate to the channel at one time. The member is carried on a moving table through guide rolls and between guide heads. This table travels at a speed of 6 in. per min while the heads are being welded and at that of 40 ft per min while skipping to the next weld. The control of the welding arc and the travel are completely automatic. The stiffeners were hand-welded to the bracing members.

There are 96± column sections approximately 50 ft long, and over 500 struts. These two items alone required 19 miles of automatic fillet weld and $3\frac{1}{2}$ tons of welding electrodes. There is considerable shop-riveted steel, such as the hanging girders and truss in the cableway system as well as the major parts of the tower tail. The elevator shaft, the trusses and hangers at the tower top, and all the house framing are of riveted construction.

Steel design in the future should utilize both welding and riveting in shop fabrication, each process to be used where it is best suited. In line with the spirit of "A Century of Progress," the design of the Skyride and Observation Tower gives an example of this modern trend.

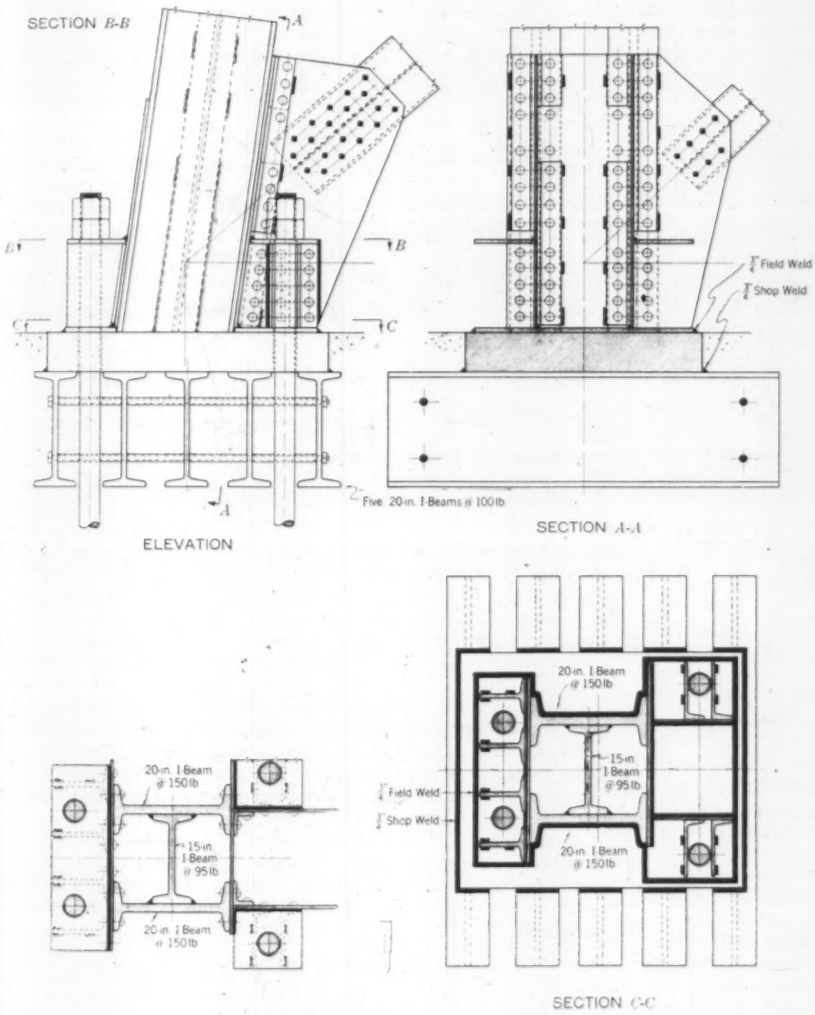


FIG. 1. DETAIL OF MAIN COLUMNS IN CHICAGO SKYRIDE
Showing Shop and Field Welds and Rivets

E. T. BLIX
Chief Engineer
Mississippi Valley Structural Steel Company

Melrose Park, Ill.
January 5, 1934

Comments on the By-Pass for Two-Lane Highways

TO THE EDITOR: The suggestion made by A. W. Robertson, in the December issue, for by-pass sidings on two-lane highways is an excellent one. He makes no stipulation as to the length of the by-pass, but presumably it would vary with the location. It does not appear that such sidings would be of great value on level or light grades on tangents. However, near the summits of heavy grades and on long curves where the view is obstructed, such additional widths would increase roadway capacity considerably. The widening should start on the grade at the point where an attempt to pass might be dangerous to the fast-moving vehicle and extend just over the summit to a point where the view is clear.

It is doubtful whether slow-moving vehicles could be induced to use the by-pass. If the driver noted a long line of fast vehicles following him, he would object to being placed in a pocket from which it might be difficult to emerge. It would probably be better to adopt the rule that fast vehicles should pass on the right by means of the by-pass sidings.

A regulation refusing permits for trailers to be attached to vehicles having a loaded speed under, say, 30 miles per hr would tend to increase the traffic capacity of highways. If slow-moving vehicles were also required, in all cases except when overtaking, to preserve a minimum interval of at least three or four vehicle lengths from other slow-moving traffic, the necessity for by-pass sidings would not be so great.

W. E. RICE, M. Am. Soc. C.E.
Associate Professor of Municipal Engineering
Case School of Applied Science

Cleveland, Ohio
December 20, 1933

Type of Fishway Construction Used in Europe

DEAR SIR: In their interesting article on "Problems of Fishway Construction," in the December number, Messrs. Baker and Gilroy suggest the use of mechanical fishways to allow fish to pass obstructing dams. In Europe where rivers have been canalized since a comparatively early time and where fishing is frequently one of the major occupations of small communities, the development of designs for fishways has attracted considerable attention.

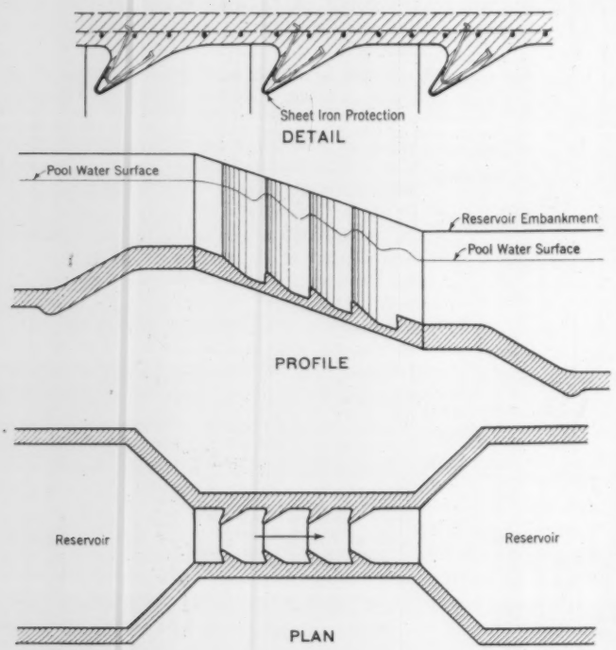


FIG. 1. "WILD-PASS" FISHWAY AS USED IN EUROPE
Details of Corrugations on Sides and Bottom of Sloping Channel; Design Used to Connect Two of a Series of Small Reservoirs

Here not infrequently mechanically operated fishways have proved very unsatisfactory.

It has been found that the fish avoid devices that operate noisily or tramsmit impact to the water. Also, it has been observed that while fish sometimes pass through ship locks in comparatively large numbers, most species tend to stay clear of mechanical devices for conveying them over the obstructing dam. There is one illustration of this fact on the Weser River near Bremen, where a fish lock and a fish stair have been constructed with their entrances adjoining each other. Practically no fish go through the lock although many use the stair.

A device that has been used considerably in Europe is sometimes referred to as the "wild-pass," or hydraulic stairs. It is used in various ways—sometimes in combination with a system

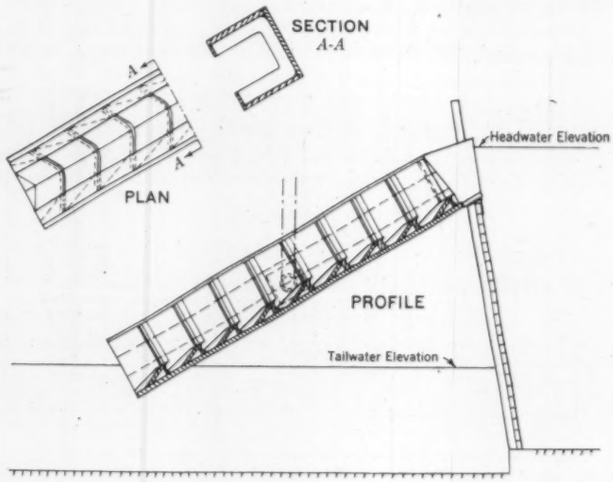


FIG. 2. A REMOVABLE FISHWAY USED FOR LOW-HEAD MOVABLE DAMS
Sides and Bottom of Channel Consist of Hook-Shaped Corrugations

of small reservoirs, as in Fig. 1, but more frequently in connection with low-lift movable dams (Fig. 2). The design was originally proposed by G. Denil, a Belgian engineer. It consists simply of a channel, usually about 2 or 3 ft wide, having large hook-shaped corrugations on the sides and bottom projecting outward from about 8 to 12 in. The spacing of the corrugations is approximately equal to the breadth of the channel. This structure is sometimes made of wood or sheet metal and, in the case of fixed structures, of reinforced concrete. The channel may be placed at a slope of about 1 vertical to 2 horizontal, whence the water velocity amounts to approximately 10 ft per sec. The velocity does not increase greatly with an increase in slope; Denil has claimed that the device may be used at slopes up to 45 deg.

A design for a device of this nature may be developed by the study of hydraulic models. The velocity will vary approximately according to Froude's model law, that is, approximately proportional to the square root of the linear dimension in homologous structures.

LORENZ G. STRAUB, Jun. Am. Soc. C.E.
College of Engineering and Architecture
University of Minnesota

Minneapolis, Minn.
December 11, 1933

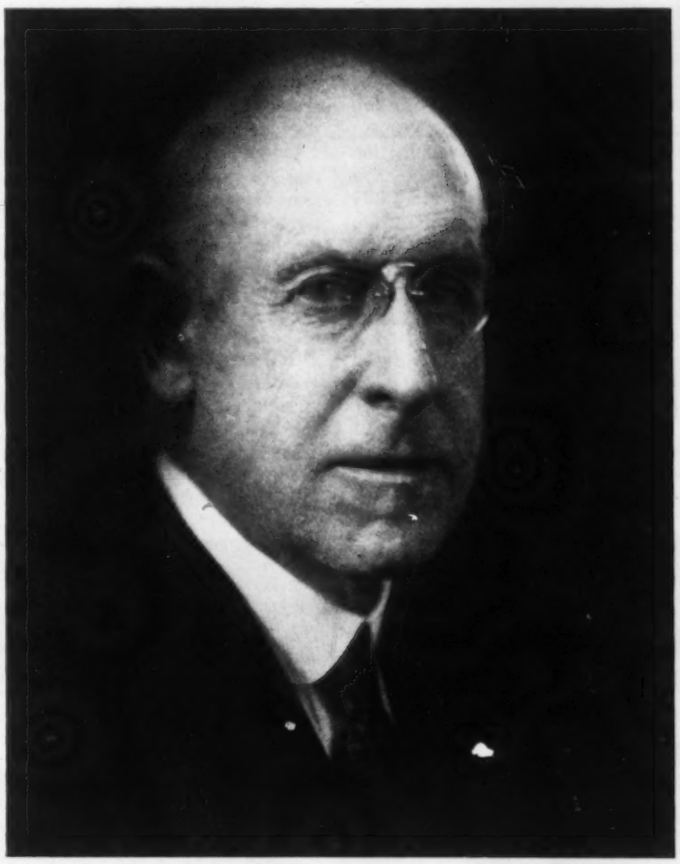
SOCIETY AFFAIRS

Official and Semi-Official

Harrison P. Eddy, President in 1934

Except for the tacit assumption that he shall be a Corporate Member of the organization, the Constitution of the Society seems to be utterly silent regarding specifications for, or qualifications of its President. Perhaps it seemed unwise to those who formulated this document to define the prerequisites too exactly. More likely, they assumed that the desired qualities of mind and heart were so obvious as not to need cataloguing. Undoubtedly the successful candidate must be a gentleman of the first rank, an engineer of eminence, a man of high idealism, a student of Society affairs, and one familiar with the organization from long experience.

These and many other high qualifications are amply met by Harrison P. Eddy, M. Am. Soc. C.E., who is now entering upon his duties for 1934 as the highest elected official of the Society. It may well be asked how, among the many thousands of qualified members acknowledged to be worthy of preferment, the selection is finally narrowed down to a single person. The answer might be difficult, but not in the case of Mr. Eddy. His ability and qualifications are so generally acknowledged that his selection may be regarded as a most natural development. His whole life and career have fitted him peculiarly for this, his greatest honor and his greatest task.



HARRISON P. EDDY
President American Society of Civil Engineers

In common with many famous engineers who have found their special field in sanitation and water supply, he hails from the Old Colony, Massachusetts. There he was born, there he went to school, there he attended college in the well-known Worcester Polytechnic Institute, from which he was graduated in 1891; and there his subsequent full and successful career was achieved. Unlike many a man in similar circumstances, he is not without honor in his own country: he has been elected to the presidency of the Boston Society of Civil Engineers, to honorary membership in the New England Water Works Association, and has been made doctor of engineering both by his alma mater and by Northeastern University. A man's status among his intimates is apt to be on the basis of frank understanding. These eminent distinctions received at the hands of those in his native state who have known him all his life are more than significant.

At the very outset of his professional career, Mr. Eddy entered the field of sanitation and served for a number of years with the City of Worcester successively as engineer in the Sewer Department; Superintendent of its Sewage Treatment Plant, at that time the largest in the country; and beginning in 1892 and for 15 years thereafter, as Superintendent of Sewers for the city. This work was peculiarly fitted to his abilities, as it included construction, operation, maintenance, and continuous research. This experimentation, particularly in the field of sewage purification, was carried on both in the laboratories and, on a large scale, in the plant itself. Even the tools, machinery, and other equipment were manufactured by direct labor under his supervision.

Beginning in 1907 there followed a life-long partnership with the late Leonard Metcalf, M. Am. Soc. C.E., under the firm name of Metcalf and Eddy, by which it is still officially known. A list of the large and important works on which the firm has served during its 26 years of existence would sound like the roster of most of the important sanitation and water supply projects in America. This practice has not only extended widely but it has gone deeply into its many allied fields, including water works, sewerage, and drainage systems; water, sewage, and industrial wastes treatment plants; and municipal refuse incinerators. Among the cities served have been Louisville, New Orleans, Rochester, Springfield, Hartford, Cleveland, Buffalo, Syracuse, Akron, Dayton, Allentown, Boston, Cincinnati, Detroit, Milwaukee, and San Antonio. In developing its work, the firm has drawn to itself a coterie of capable men who, in conjunction with its notable technical achievements, have gained for it an unusually enviable reputation.

Starting in the field of sewage works, Mr. Eddy has continued to grow with this fast-developing science. His experience has brought him into practical contact with all the processes of treatment in more or less common use today. These include sedimentation, septic tank treatment, chemical precipitation, intermittent filtration, continuous filtration through trickling filters, purification by means of aeration and activated sludge, and many processes and combinations of processes used in the treatment of industrial wastes. He is also an authority on the treatment and disposal of sewage solids or sludge by lagooning, draining, and drying on sand beds; on bacterial digestion in different kinds of tanks and at various temperatures; and on dewatering in filter presses and by vacuum filters. In addition to routine operation, this work has involved continuous research in the sciences underlying such processes and in the application of these sciences to treatment.

As a logical outcome of his intimate acquaintance with these technical questions, his services have been frequently commandeered on many important court cases. Four of these Mr. Eddy has attended as expert witness before a special master appointed by the U. S. Supreme Court, including New Jersey vs. New York, and Wisconsin et al vs. Illinois and the Sanitary District of Chicago, dealing with sewage disposal; and New Jersey vs. New York and Connecticut vs. Massachusetts, relating to water supply.

Likewise his services have been in demand on engineer commissions, including the classic Engineering Board of Review of Chicago, working on the lake-lowering controversy and the program of

remedial measures. Still another commission on which he served had to do with the general plan, design, construction, and operation of the sewage treatment plant of the North Toronto District and on the sewage disposal problem of the entire Canadian city.

Among the projects on which he is now engaged are sewage problems for the District of Columbia in the East, and for the City of Portland, Ore., in the West. At the same time he is a member of the Technical Board of Review, which is advising the Public Works Administration in Washington with respect to applications for Federal aid in carrying out those of its projects which are unusual and which are of a controversial nature.

In spite of his otherwise busy life he has found time to devote to technical writing. Not only has he a wide understanding of sanitary matters as an exhaustive student, but he has contributed toward the better understanding of his professional associates. He is widely known as co-author of the three volumes of *American Sewerage Practice* and of *Sewerage and Sewage Disposal*.

Many technical papers and reports also have appeared under his name. The quality of this work is attested by the award of the Desmond FitzGerald Medal from the Boston Society of Civil Engineers, and that of the Rudolph Hering Medal and the Norman Medal from the Society, the latter the highest literary distinction in the profession.

As a member of the Board of Direction of the Society, Mr. Eddy was an indefatigable worker. While he was chairman of its Committee on Publications, the significant decision was made to inaugurate CIVIL ENGINEERING. The boldness of this step was questioned at that time, but Mr. Eddy, confident in the strength of his position, never questioned that it was entirely justified.

During his long period of association with the Society, he has served in many other difficult capacities. Committee work of an arduous nature has never appalled him. He is now active on the Committee for Professional Development and the Committee on Public Works.

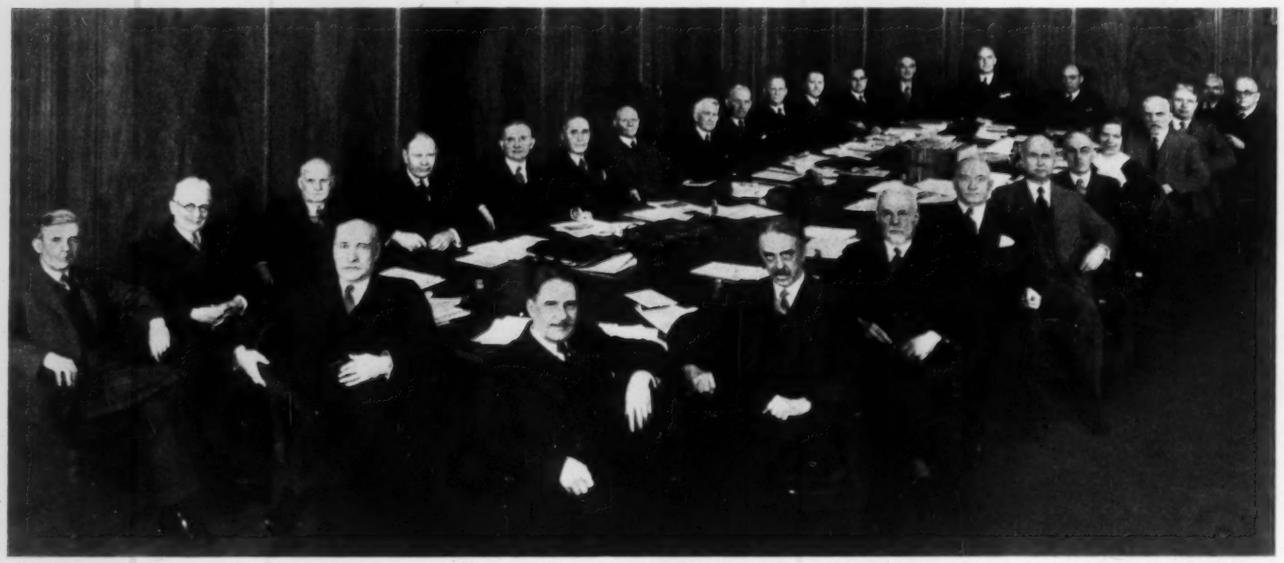
In the face of such a notable array of accomplishments, a natural question arises—what sort of person is this, who has accomplished so much and so well? In meeting him, he impresses one as thoughtful yet genial, serious yet kindly. One trait that has stood out through all the years is his willingness to bestow freely of the benefit of his experience on the younger men who feel the need of advice along the road toward engineering as a profession. As his own career has developed, his advice has been more valuable and more urgently sought, but not a whit less freely given.

He is not one to jump at a decision; rather, he works cautiously but surely in his analysis. His is an unusual ability to grasp new problems. When his analytical mind has penetrated an engineering study and thrown light on its weak points, this faculty does not blind him to its merits as well. A certain judicious trait enables him to weigh the pros and cons, and when all the arguments have been concluded, his judgment will be remarkably lucid and is likely to prove itself justified in the sequel. Another phase of this same quality shows itself especially in times like the present—he keeps a level head and seldom shows discouragement. He is willing to view the facts candidly and abide by the weight of the evidence. This characteristic of keeping himself in complete command at all times, even under the most trying circumstances, is certainly a valuable attribute in one who must represent the diverse interests of an organization such as the Society.

On the quantitative as well as on the qualitative side, he commands attention. Among his associates he is known as a tremendous worker, perhaps too much so for his own good at times. He is not afraid to set the pace, and he expects others to follow. Details are not boresome to him; at least he is willing to tackle them. Yet they do not blur his broad vision of the problem as a whole.

Many engineers have been privileged to know Mr. Eddy as a friend as well as a colleague. They will testify that he is a delightful companion at all times, that he shines in his home and elsewhere as a gracious host, that his friendship is always considerate and sympathetic. While reserved in his public expressions, there is no lack of inherent warmth and sincerity. Only his intimates know the burdens he has carried during difficult years, burdens made heavier by his desire to be of the utmost assistance to those in need, and yet carried cheerfully and without complaint.

In such a man the Society reposes confidence for the year 1934



1933 BOARD OF DIRECTION OF THE SOCIETY

The 1933 Board of Direction finished its business at the session held on January 16, 1934, just prior to the Annual Meeting in New York, N.Y., and turned over its unfinished business to the new Board, which held its first meeting shortly thereafter. Beginning at the nearest corner of the table, and proceeding around it in a clockwise direction, those present at the final session of the meeting of the 1933 Board of Direction were, as photographed here: J. C. Stevens, Director, District 12; Francis Lee Stuart, Past-President; L. G. Holleran, Director, District 1; Arthur S. Tuttle, Vice-President, Zone I; Frank G. Jonah, Vice-President, Zone III; E. B. Black, Director, District 16; H. D. Mendenhall, Director, District 10; Herbert S. Crocker, Past-President; D. C. Henny, Vice-President, Zone IV; E. K. Morse, Director, District 6; Henry J. Sherman, Director, District 4; John H. Gregory, Director, District 5; Ralph J. Reed, Director, District 11; W. W. Horner, Director, District 14; F. C. Herrmann, Director, District 13; J. P. H. Perry, Director, District 1; E. N. Noyes, Director, District 15; James F. Sanborn, Director, District 1; Henry E. Riggs, Director, District 7; M. L. Enger, Director, District 8; Otis E. Hovey, Treasurer; Carolina Crook, Secretary to Mr. Seabury; George T. Seabury, Secretary; Alonzo J. Hammond, President, 1933; Edward P. Lupfer, Director, District 3; Charles A. Mead, Director, District 1; and Henry R. Buck, Director, District 2. Absent: Frank O. Dufour, Vice-President, Zone II; and Robert Hoffmann, Director, District 9.

Secretary's Abstract of Executive Committee Meeting

On December 15, 1933, the Executive Committee met at Society Headquarters with President Alonzo J. Hammond in the chair. Present were: C. E. Beam, Assistant Secretary, acting as Secretary; Otis E. Hovey, Treasurer; and Messrs. Mead and Tuttle. The incoming President, Harrison P. Eddy, was present by invitation.

Approval of Minutes

The minutes of the meeting of the Executive Committee held on September 25, 1933, were approved.

Proposed Budget for 1934

The Budget for 1934 was prepared for presentation to the Board of Direction at its meeting in January, and other routine matters of Society business were considered and acted upon.

Evolution of the Society Badge

THERE IS something distinctive about the shape of the Society badge which seems to make it readily identified. Conversely, any deviation also becomes quickly apparent and is the object of immediate criticism. None of the substitutes seem to equal the official design in grace. It is of interest, therefore, to note how this particular design was developed.

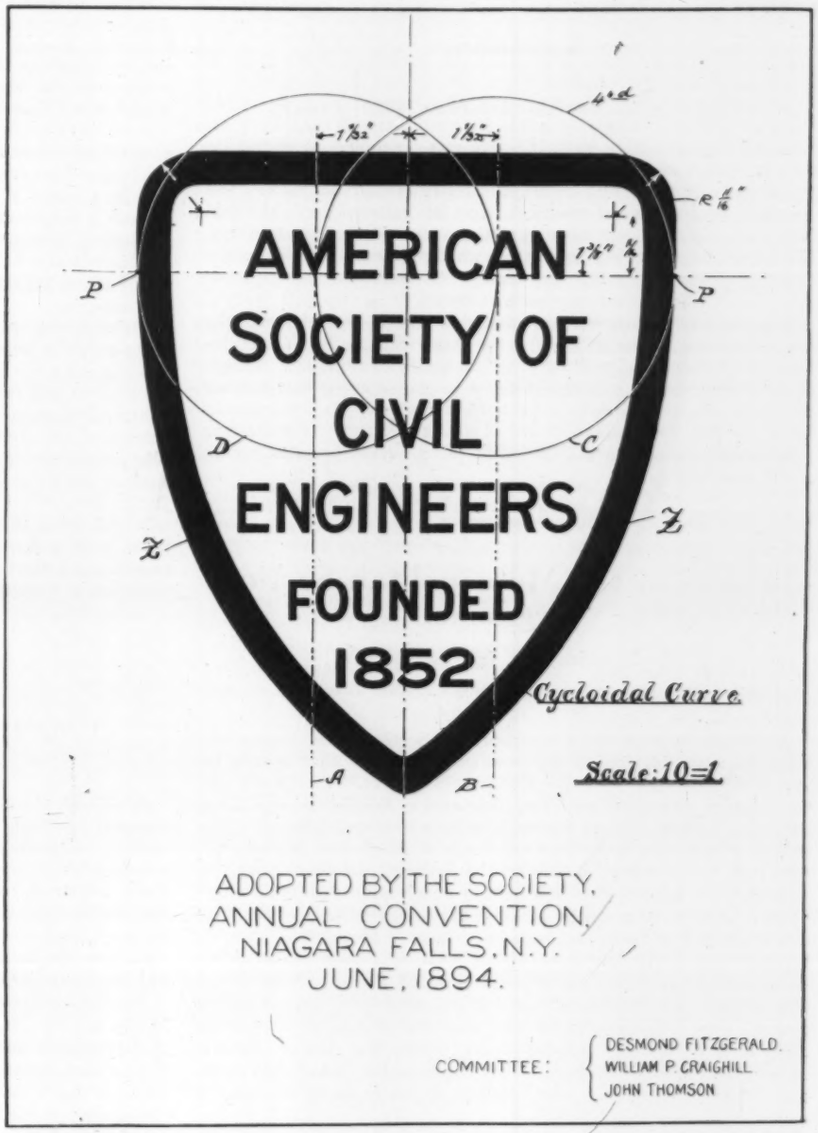
Many may not realize that today there are two official and entirely distinct badges for Corporate Members. The older style, somewhat wider than the present, carries the notation, "A. S. C. E. 1852" and shows a wye level occupying the lower half. Although no badges of this type were issued after 1894, a few of them are still in existence and in constant use. It goes without saying that their owners are not a little proud to exhibit their long-standing affiliation with the organization.

In 1894 the shape was changed somewhat by reducing the width, removing the level, and spelling out the Society name. The result was the badge as most people know it today. It proved to be rather difficult to maintain the exact shape. In the course of years, succeeding manufacturing jewelers altered the outline somewhat so that eight or ten years ago the change became noticeable. Although the desire was to return to the official shape, for a long while it was impossible to determine what was the proper basis for design. Even the exact dimensions were in doubt, and for a time previous models of the badges themselves were the only guide.

Enlarged photographs were prepared and attempts were made to fit compound arcs to the outline. At best these efforts were far from successful for the good reason, as later learned, that the shape was formed by developed curves and not by circular arcs at all. Study disclosed the fact that the official design had been approved by the Society itself at its Annual Convention in 1894. One of the members of the committee which drew up the design, John Thompson, M. Am. Soc. C. E., a former treasurer, was still alive. He distinctly remembered the general facts and gave generously of his time in having prepared elaborate new designs in an attempt to duplicate the approved design of 1894.

Meanwhile hope of finding this original had not been given up. Search at Society Headquarters was continued intermittently over a period of months, without avail. Eventually and entirely by accident, among a mass of old papers, a white print was found, giving the shape of the badge to an enlarged scale. It was immediately identified as the original, and new dies were ordered, strictly adhering to the correct shape.

As will be noted from the reproduction of the standard design herewith, the dimensions are given to a scale of 10 to 1. No over-all dimensions are indicated but they may be computed. For example, the width is 6 1/16 in., and hence the absolute width of the badge is 0.606 in. For a very short distance the upper part of the sides of the badge is straight; the lower are cycloidal curves generated by a point on a 4-in. circle that rolls downward along a vertical axis. The mathemati-



FROM ORIGINAL DRAWING OF OFFICIAL BADGE ADOPTED 40 YEARS AGO
Reduction Is One-Half Original Size, That Is, Scale of Reproduction Is 5 to 1

cally minded can compute the point of intersection of these two side curves. The depth of the badge on the print actually scales 7.25 in., so that the pin itself should be 0.725 in. long.

Besides their historical interest, these details have a practical application. In general the use of the Society badge is limited to official Society activities. All sub-organizations should obtain approval before using any reproduction of the badge. This is obviously necessary as a protection to the membership. It does not apply to the Local Section insignia or seal. Even these, however, are subject to similar provision in that they require the approval of the Local Section for use in other than the Section's own activities.

When used in replica form or even when used for decorative purposes, the shape should be accurate. For this purpose, the details here given will be of use. In view of the general interest of members in this subject and in response to request for details, the foregoing information is given to put the matter definitely on record. The Society seal always has been, and rightfully should be, a matter of pride to each member. Protection of its value is therefore an obvious duty.

Report on Stresses in Railroad Track

IN 1914 a committee of the Society was organized to cooperate with a similar committee of the American Railway Engineering Association to study and report on stresses in railroad track. The complete committee, of which Arthur N. Talbot, Hon. M. Am. Soc. C.E., has been continuously chairman, consists of 18 members. It has been a continuing committee, which not only has outlined a program of procedure but has carried out countless tests in laboratory and field and interpreted the results.

The Sixth Progress Report has now been presented to the sponsoring organizations and to the American Railway Association, which has furnished the principal financial support. A copy of this rather voluminous report has been placed in the Engineering Societies Library, where it is available for study. It is being published in the *Proceedings of the American Railway Engineering Association*, where also will be found the previous progress report of this committee.

Juniors of the Metropolitan Section Organize

By C. SCHROEDER, JUN. AM. SOC. C.E.

JUNIOR ENGINEER, TRANSIT COMMISSION, NEW YORK, N.Y.

A RECENT activity of the Metropolitan Section of the Society has been of such service to its younger members that it may be worth consideration by other Sections elsewhere. Two years ago the Section sponsored an interesting course in effective speaking for the benefit of Juniors who were members of the Section. This course, which was under the direction of Alexander Haring, M. Am. Soc. C.E., was given free to the Juniors. In developing the ability of the participants in a field in which almost all older engineers confess to be woefully lacking, the art of self-expression, the course served its purpose very effectively. More than that, it brought together a group of young men who soon realized the social and professional advantages afforded them by this closer association. Consequently, at the completion of the speaking course, they organized with the sanction of the Metropolitan Section a permanent self-governing body, the Junior Branch of the Metropolitan Section. This organization, which has operated without dues, has now functioned continuously for over a year.

The immediate purpose of the Junior Branch is twofold: to secure training and practice in effective speaking and to provide an agency through which the Juniors can work with the Section and the Society more directly. Incidentally, the Juniors have an exceptional opportunity to get to know each other.

Meetings are held at 8:00 p.m. on the second and fourth Tuesdays of every month at Society Headquarters, 33 West 39th Street, New York, N.Y. Each meeting consists of a business session and a speaking session. The speaking sessions are conducted with a system of rotating chairmen, which provides a new chairman for each session and thus ensures every member a turn at the chairmanship. During these sessions the time is divided up so as to provide for impromptu speaking, prepared talks, a period of instruction, and occasionally an address by some prominent speaker. Impromptu talks are based on a series of current topics selected by the chairman, and every member present is required to discuss one of these topics. For the prepared speeches the topics are selected by the members themselves. At least one such speech a month is expected from each member.

At present the instruction is provided by the chairman, who is assigned a definite phase of the subject from a prearranged outline and supplied with suitable texts to aid him in preparing the material. It is also his duty constructively to criticize the other speakers. A regular instructor may be secured again in the near future.

Arrangements have been made to have some prominent speaker address the group on regular occasions. On January 23 the member had the pleasure of listening to an interesting talk by Robert Ridgway, Past-President Am. Soc. C.E. An annual speaking contest is held in the spring. This contest takes place at a regular meeting of the Metropolitan Section, and prizes are awarded by the Section's Committee on Juniors.

A member of the Junior Branch has been appointed to serve on each of the standing committees of the Metropolitan Section. At the business sessions of the Junior Branch, these Junior committee members make reports which have helped greatly to give the Juniors a better understanding of the Society work of the older members. Suggestions for new activities are always received enthusiastically at the business sessions, as it is realized that the life of any organization depends on two things, new activities and new members.

Through the activities of the Junior Branch real progress is being made in improving materially the present status and future opportunities of the Juniors both as individuals and in relation to the Society and the profession. All Juniors residing in the Metropolitan District are eligible to attend and participate. The 1934 officers of the Junior Branch are John J. Knox, President; C. Schroeder, Vice-President; and George S. Teter, Secretary, all Juniors Am. Soc. C.E. The details of the organization of the Junior Branch in New York will probably require modification to suit the local conditions peculiar to other Sections, especially those with a large Junior membership, but the general plan of encouraging more participation in Society activities by younger members is worthy of consideration.

General Assembly of the Construction League Meets

IN WASHINGTON, D.C., on February 1 and 2, the regular annual General Assembly of the Construction League of the United States meets. Important governmental policies vitally affecting the construction industry are to be considered, such as the Construction Code, awaiting presidential approval as this item goes to press; the Public Works program; recommendations for reviving industry; and means of unifying the various branches of construction—professional, producing, installing, and erecting—to aid the recovery program.

Representatives of the Society at the General Assembly of the league will be: Harrison P. Eddy, President Am. Soc. C.E.; Alonzo J. Hammond, and Herbert S. Crocker, Past-Presidents Am. Soc. C.E.; and Frank A. Randall, M. Am. Soc. C.E. The terms of office of the General Chairman, the Second Vice-President, and the Treasurer of the League expire with this meeting, and the incumbents of these positions have been nominated by the Policy Committee for election to succeed themselves, as follows: for General Chairman (one year), Alonzo J. Hammond, Past-President Am. Soc. C.E.; for Second Vice-President (two years) A. P. Greensfelder, M. Am. Soc. C.E.; and for Treasurer (two years), J. C. Bebb.

Final Ballot on Society Officers for 1934

33 West 39th Street
New York, N.Y.
January 10, 1934

To the Eighty-First Annual Meeting
American Society of Civil Engineers:

The tellers appointed to canvass the ballot for officers of the Society for 1934 report as follows:

Total number of ballots received		3,009
Deduct:		
Ballots from members in arrears of dues	55	
Ballots not signed	32	
Ballots with indecipherable signatures	1	
Total withheld from canvass		88
Ballots canvassed		2,921
For President		
Harrison Prescott Eddy	2,913	
Scattering	4	
Blank	4	2,921
For Vice-Presidents		
Zone I:		
John Philip Hogan	2,866	
Scattering	8	
Blank	47	2,921
Zone IV:		
Henry Dievendorf Dewell	2,888	
Scattering	1	
Blank	32	2,921
For Directors		
District No. 1 (Two to be elected):		
Othmar Hermann Ammann	2,809	
Charles Eliphalet Trout	2,813	
Scattering	6	
Blanks	214	
Total votes registered		5,842
Total ballots canvassed		2,921
District No. 2:		
Frank Alexander Barbour	2,887	
Scattering	2	
Blank	32	2,921
District No. 6:		
Thomas Jefferson Wilkerson	2,887	
Scattering	1	
Blank	33	2,921
District No. 10:		
Frederick Honour McDonald	2,883	
Scattering	3	
Blank	35	2,921
District No. 13 (Two candidates, one to be elected):		
Bernard Alfred Etcheverry	1,124	
Thomas Elwood Stanton, Jr.	1,091	
Scattering	2	
Blank	704	2,921

Respectfully submitted,

E. R. NEEDLES, *Chairman*

Paul A. Kelly	C. Raymond Weaver	Charles D. Thomas
Hiram Miller	William E. Brown	Thomas H. Jones
Wm. N. Hazen	William F. von Buehren	Irving Jacobs
Arthur A. Carman	J. D. Moore	Reuben Kosches
J. J. Hennebique	Alfred Brahdy	*Tellers*

Revisions for 1934 Year Book

IN order that the 1934 *Year Book*, which will shortly go to press, shall be as accurate as possible, it is essential that corrections, if any, be submitted at once. Since the previous issue was distributed, many changes of address—probably thousands of them—have been forwarded and these have already been incorporated in the revised list. In addition there are undoubtedly many other members whose latest titles and addresses are not as yet on file. Those members who previously have not notified Headquarters of any changes since the March 1933 issue of the *Year Book* was issued, should submit such revisions not later than February 20, 1934, in order that they may be included in the forthcoming volume.

American Engineering Council Elects New Officers

AT THE ANNUAL meeting of the American Engineering Council, held in Washington, D.C., January 11, 12, and 13, 1934, John F. Coleman, Past-President Am. Soc. C.E., was elected president and Frederick M. Feiker, formerly Director of the Bureau of Foreign and Domestic Commerce, was appointed executive secretary of the Council. Other officers representing the several national and local engineering societies were elected as follows: For vice-presidents of the Council, C. O. Bickelhaupt, Vice-President of the American Telephone and Telegraph Company, New York, representing the American Institute of Electrical Engineers; Paul Doty, President of the American Society of Mechanical Engineers, representing that society; A. J. Hammond, Past-President Am. Soc. C.E., representing the American Society of Civil Engineers; W. H. Woodbury, Duluth, representing the local engineering societies. Also C. E. Stephens, of the American Institute of Electrical Engineers, was elected treasurer and William McClellan, President of the Potomac Electric Power Company of Washington, was elected chairman of the Finance Committee.

Epitome of Society Progress for Past Year

EXTRACT FROM THE ANNUAL REPORT OF THE BOARD OF DIRECTION FOR 1933

A COMPREHENSIVE analysis, made in the early part of this year by the Society's Committee on Salaries, shows the 31st of December 1930, to have been the moment of greatest employment of civil engineers for all time in this country. That survey also shows decrease of employment of civil engineers persistently since that date and permitted the estimate that on December 31, 1933, there would be between 45,000 and 50,000 civil engineers and engineering assistants out of employment. The survey indicates, further, that by that time 28,000 would have been out of employment for a period of one year or more, and 12,000 for two years or more.

The figures are impressive but they are figures only. The individuals, members of this Society, and otherwise, concerning whom these figures were compiled, are trained men upon whom the accident of unemployment for one, two, and even three years inflicted untold hardship and privations.

It should be no occasion for wonder, therefore, that the activities of the Society during the past year turned abruptly into new lanes of endeavor. Many activities formerly valued were sharply limited in scope and both energy and money diverted to activities hitherto not fully developed or even engaged upon.

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In 1932 the Board of Direction urged the stimulation of public works construction as a measure capable of being of assistance in the restoration of general business. A Committee on Public Works was appointed and addressed itself actively to the passage by the Congress of the United States of measures permitting the extension of Federal credit to political subdivisions for their aid in the restoration of a normal program of public works construction. The application of Federal credit through the Reconstruction

Finance Corporation was the result. This year, at the instance of the Board of Direction, equally active effort was made to effect through the Congress an extension of Federal credit to a larger field of construction activities by the political subdivisions. The authorization of $3,300,000,000 for the furtherance of public works construction through the Public Works Administration eventuated, and by the end of the year, although by no means fully effective, an increase in employment of civil engineers and of general construction labor, both at the site and at the place of fabrication, was measurable.

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Under the National Recovery Administration and in accordance with the spirit of the National Industrial Recovery Act, the Society joined in a determined and long-sustained effort to consolidate the several elements of the construction industry, design, general contracting, and subcontracting. Under the sponsorship of the Construction League of the United States, of which the Society is a member, a general Code Committee was appointed with engineer participation and, since July 1933, has sought to determine a basic or master code. This eventually took the form of a series of chapters, of which Chapter I includes all features that can be made uniformly applicable to all the major elements of the industry, and of which subsequent chapters deal specifically with the unfair practices and the methods of administration incident to each of the major elements.

Work upon a chapter for the Engineers' Division has been continuous since July. . . . It has been an effort requiring almost infinite patience. . . . At the close of the year the Engineers' Code was undergoing a tentative revision looking toward a broadening of the field so as to be inclusive of engineering as it is practiced in the design and installation of special methods and processes.

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Again this year a strong effort has been made by the Local Sections of the Society to seek out and assist those engineers upon whom the problems of unemployment have rested heavily.

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Continuing its policy of the previous year the Board of Direction has extended the privilege of suspended dues to those members who have loyally supported the Society in times past. . . . The effect of the depression upon Society members as indicated by failure to pay dues has shown an increase this year as compared with 1932. . . . In 1932, delinquency in payment of dues was 16 per cent; in 1933, it was 24 per cent.

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In conformity with decreased income, expenditures were decreased for publications, for support of Local Sections, for research, administrative, professional, and technical committees. The Spring and Fall Meetings were omitted. The salaries of the staff were decreased. The intent at the time of the preparation and later modifications of the Budget was to expend a reasonable amount in excess of income. However, as a result in part of a reverse in the trend of payment of dues in the last three months of the year, the year closed with an excess of income over expenditures equal to $16,184.00, an amount, incidentally, closely approximating the sum to be paid, early in 1934, on the mortgage.

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The total number of applications for membership was 887, of which 715 were for admission and 172 for transfer. . . . The losses by death during the year number 169. Membership in the Society on the first day of the year was 15,201, a decrease of 46 over that of a year ago.

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The Employment Service has offices in New York, N.Y., Chicago, Ill., and San Francisco, Calif. The number of men placed during 1933 has averaged about 72 per month.

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In 1933, the Society published two volumes of TRANSACTIONS (97 and 98), 10 numbers of PROCEEDINGS, 12 numbers of CIVIL ENGINEERING, and a *Year Book*.

Of the two volumes of TRANSACTIONS, Volume 97 is made up of the papers and discussions describing the various design and construction problems of the George Washington Bridge, written by the Engineers of the Port of New York Authority engaged on the work. Volume 98 is the regular yearly issue of TRANSACTIONS.

During the year progress reports of the Special Committee on Meteorological Data and the Special Committee on Earths and Foundations, and the Third Progress Report of Subcommittee No. 31, Committee on Steel, of the Structural Division, on Wind-Bracing in Steel Buildings were published in January, May, and December PROCEEDINGS, respectively. There have also been published in PROCEEDINGS 30 papers and 1 symposium, together with the discussions thereon, and also a number of discussions of papers published in 1932. . . . Discussions of papers, etc., published in PROCEEDINGS for 1931 and 1932, to the number of 121 were also included in the 1933 issues, making a total of 240 authors and discussers.

Special issues of CIVIL ENGINEERING for the year included the March, . . . the August and September numbers covering abstracts [of meeting papers]. . . . The remainder were regular issues. In all, 144 papers appeared during the year, including the abstracts. In addition, 21 brief papers under the heading "Engineers' Notebook," were printed. Discussions and comments to the number of 129 contributions were scattered throughout the 12 issues. . . . The program for the Annual Meeting was issued complete in the January number and that for the June Convention, in the June number.

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Since October 1930, approximately 400 memoirs have been issued, many of which have been included in TRANSACTIONS, Vol. 95 (1931), Vol. 96 (1932), and Vol. 98 (1933).

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The attendance at the Reading Room during the year was 4,014 Two hundred and sixty periodicals are regularly received. Included in this number are many foreign periodicals, also a number of literary magazines and several daily newspapers.

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The number of Local Sections, 56, is unchanged since last year no Section having been organized or disbanded during 1933.

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All but one of the Technical Divisions of the Society held sessions during the year, either at the Annual Meeting in New York in January, or at the Annual Convention in Chicago in June. Of these meetings, five were double sessions, of which four were held jointly with similar divisions of other societies at the Annual Convention during Engineers' Week of the Century of Progress.

The meetings of the Divisions were marked by good attendance and interest and by an excellent group of technical papers. Abstracts of all the presentations appeared, either in the March or the August and September issues of CIVIL ENGINEERING. In addition, some of the papers are being prepared for publication in more complete form in PROCEEDINGS and TRANSACTIONS.

There are now a total of 14,857 members enrolled in the 10 Technical Divisions, divided among them as follows: City Planning, 1,532; Construction, 2,671; Engineering-Economics and Finance, 457; Highway, 2,190; Irrigation, 941; Power, 870; Sanitary Engineering, 1,640; Structural, 2,789; Surveying and Mapping, 895; and Waterways, 872.

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There are at present 109 Student Chapters. The following were organized during 1933: D. B. Jett (New Mexico State College), Duke University, Lewis Institute, South Dakota State College, Texas Technological College, and Tulane University.

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The balance sheet accompanying the report of the Secretary shows that, of the total assets of over $1,400,000, nearly $1,100,000 represents the value of real estate, that is, the Society's property on 57th Street and its interest in the Engineering Societies Building.

The expenditures of the Society for the year totaled $361,500, of which $162,000 was taken from dues and entrance fees, and $52,500 from income derived from the 57th Street property.

(The complete annual report of the Board of Direction for 1933 will appear in the February 1934 issue of PROCEEDINGS.)

The Eighty-First Annual Meeting Is Held in New York

PRECEDED by business sessions of the Board of Direction on Monday and Tuesday, the Eighty-First Annual Meeting of the Society was called to order at ten o'clock on Wednesday morning, January 17, 1934, by President Hammond. The auditorium of the Engineering Societies Building was comfortably filled by a representative body of members from all parts of the continent and by a liberal number of guests. An important feature of the session was the presentation of the Annual Report of the Board of Direction. Then Frederick E. Turneaure, M. Am. Soc. C.E., was conducted to the platform, where he was greeted by Past-Presidents and Honorary Members and by Otis E. Hovey, M. Am. Soc. C.E., who presented him to President Hammond. After Honorary Membership had been conferred on him by the President, Dean Turneaure, in his gracious speech of acceptance, stated that he was pleased not only personally but also because of the recognition thus given to the work of engineering teachers.

PRIZES ARE AWARDED

As the next feature of the program, seven medals and prizes were presented for papers published in the TRANSACTIONS of the Society. As each recipient was introduced, a brief sketch of his career and an explanation of the prize were given, similar to those included in the January issue of CIVIL ENGINEERING. In an effective ceremony the John Fritz Medal, which had been awarded to the late John R. Freeman, Hon. M. Am. Soc. C.E., was received by his son, John R. Freeman, Jr., on behalf of the family.

Progress reports of three Society committees and the final report of one committee, that on Irrigation Hydraulics, were read. After discussion from the floor on the subject of the Code of Ethics, the question of adding the seventh section to it (CIVIL ENGINEERING, November 1933, pages 638, 643) was referred to the Board of Direction for further consideration. The report of the tellers on the canvass of final ballots for the election of officers (printed elsewhere in this department) was next read, and those indicated were declared duly elected. After being conducted to the platform by a committee of Past-Presidents, President-elect Harrison P. Eddy, M. Am. Soc. C.E., was installed as the chief guiding officer of the Society for 1934. In an optimistic speech Mr. Eddy briefly expressed his conviction that the outlook for the profession in the coming year was brighter than it had been at any time since the economic depression began. He imparted his enthusiasm to the meeting.

LUNCHEON AND GENERAL SESSION

Adjournment of the morning session was immediately followed by a buffet luncheon in the Engineering Societies Building. Here a good opportunity was given for friends to find each other and for new friends to be made.

In the afternoon a problem in government ownership was taken up at the general session under the leadership of the Engineering-Economics and Finance Division. The principal speaker presented a thought-provoking address on the difficulties inherent in government operation of power-producing facilities. He suggested a government-owned super-power system drawing power from the Colorado, the Tennessee, the St. Lawrence, and the Columbia rivers, which would retail power in large blocks for distribution by privately owned utility systems.

TECHNICAL DIVISIONS MEET

Thursday was given over entirely to sessions of Technical Divisions. Such a variety of subjects was scheduled for concurrent meetings that members were often hard put to it to choose among them. Six Divisions—City Planning, Construction, Sanitary Engineering, Highway, Waterways, and Structural—presented programs. As usual, abstracts of the papers read will appear in the March number of CIVIL ENGINEERING.

VARIED ENTERTAINMENT PROVIDED

Although the meeting filled four days, only one of them was taken up by a strictly technical program. Members found ample opportunity to get together at entertainments, luncheons, inspection trips, and of course, the Smoker. The principal social event was the dinner dance in honor of the new President and the Honorary Member, held on Wednesday night in the Grand Ballroom of the Roosevelt Hotel. There President Eddy and Dean Turneaure received, an enjoyable dinner was served, and dancing and entertainment were provided.

On Thursday night, 1,100 men filled to overflowing the Engineering Societies Auditorium to hear the renowned aviator, Capt. A. W. Stevens, U. S. Army, tell of his experiences in aerial photography and aerial exploration and of his proposed balloon flight this spring to the stratosphere. His address was followed by refreshments and "smokes" on another floor. In the auditorium a large repertoire of motion pictures of engineering interest was exhibited.

LADIES TIME ALSO FILLED

Nor were the ladies neglected by the Committee on Arrangements. The Engineering Woman's Club made its facilities available to them and assisted in arranging special trips and in furnishing information. On Thursday they were entertained at a fashion show and tea at the Roosevelt Hotel, followed by a buffet suppre at the Engineering Woman's Club.

In perhaps the crowning event of the week, the ladies joined the men in an all-day excursion to Rockefeller Center. There the management provided an opportunity to see the back-stage theater equipment, the radio broadcasting facilities, and the observation tower of the 70-story R.C.A. Building. No one could fail to be impressed by the great variety of engineering ability required in the construction and furnishing of that giant group of buildings. After a delicious luncheon served by Sherry's far above Fifth Avenue, on the 63d floor of the R.C.A. Building, seats were made available at the Music Hall theater, where a stage spectacle and a motion picture were enjoyed by all.

Saturday was devoted to three inspection trips—to the Museum of Science and Industry, the Commerce Building of the Port of New York Authority, and the Brooklyn Navy Yard.

ATTENDANCE RECORDED

Although accurate count of those in attendance at the many meetings and functions was not possible, the following approximate figures were collected for the record:

Total registration			1,550
Business meeting, Wednesday morning			400
General session, Wednesday afternoon			150
Luncheon Wednesday			310
Dinner dance			300
Sessions of Technical Divisions:			
City Planning	160	Highway	70
Construction	80	Waterways	70
Sanitary Engineering	120	Structural	400
Smoker			1,100
Ladies fashion show and tea			300
Excursion to Rockefeller Center			400
Inspection trips:			
Musem of Science and Industry			130
Commerce Building, Port of New York Authority			60
U. S. Navy Yard			150

MUCH CREDIT DESERVED BY COMMITTEE IN CHARGE

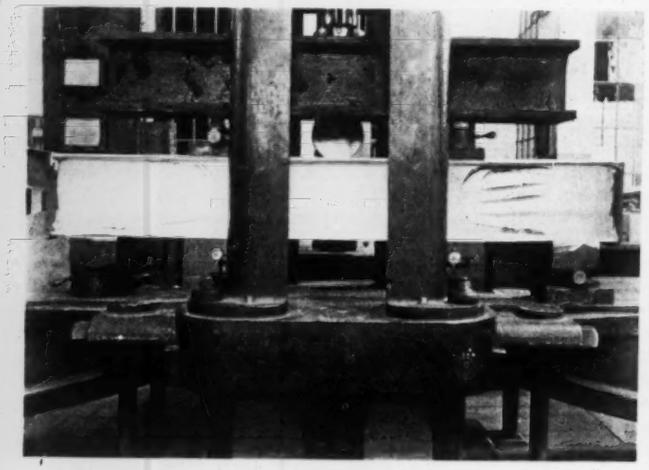
The smoothness with which every part of the week's activities proceeded is ample evidence that the committee in charge had slighted no phase of its task. Special credit is deserved by those who arranged for the entertainment of the ladies. The statement that the meeting was a great success professionally as well as socially can be verified by all who attended. A spirit of optimism and faith in the future pervaded the gatherings.

A Preview of Proceedings

The group of papers in preparation for the February PROCEEDINGS *has wide interest and engineering appeal. It includes such subjects as construction for resisting earthquake shocks; an analysis of long-time rainfall records for New York; the movement of sand in river models; and a laboratory investigation on web buckling in steel beams. These papers will appear in the forthcoming issue as space permits, together with the Annual Report of the Board of Direction and discussions of papers previously published.*

FLEXIBLE "FIRST-STORY" CONSTRUCTION FOR EARTHQUAKE RESISTANCE

OF ESPECIAL INTEREST, particularly to structural engineers on the Pacific Coast, is the paper by Norman B. Green, structural engineer of San Francisco. It is intended to give a practical method of designing steel frame buildings to resist earthquakes. The new



LOADING ARRANGEMENT OF BEAM NO. 3, A 12-IN. 28-LB I-BEAM
With Welded End Plates Showing Web Failure Due to Shear

municipal building ordinances for example, now being prepared in all the larger cities in that region, are intended to provide for this hazard. They will make the economical construction of higher buildings rather difficult unless some method of using the flexible type of design is advanced.

The subject is one that has received too little attention. At present there are two distinct schools of thought: one which advocates making the structure as rigid as economically possible, and the other which believes that the first story, or the basement story, should be made flexible to absorb the motion of the earth. Mr. Green's equations are derived for the latter case. His purpose is only to outline a method of analysis, and he has made no effort to show definite conclusions regarding the relative practicability of either type.

RAINFALL STUDIES FOR NEW YORK, N.Y.

IN HYDROLOGY, as in history, the best guide to the future is in the past. Hence, in studying trends of rainfall in connection with his drainage work for the New York City subways, Samuel D. Bleich had recourse to one of the old and convenient records. Data from the Central Park gage have been kept continuously since 1869. The series, extending through the year 1930, form the basis of these studies.

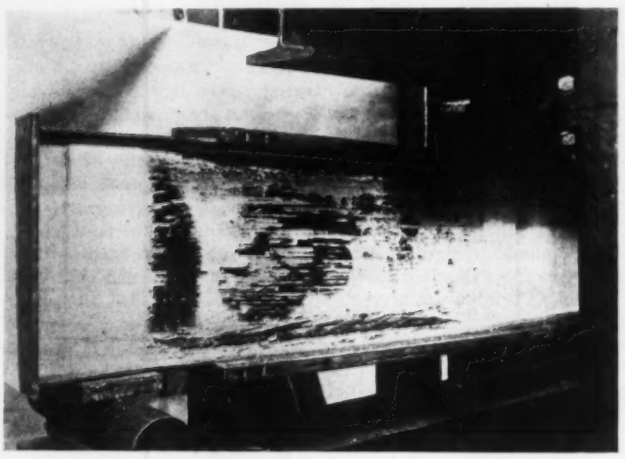
Several basically different types of precipitation formulas were tried. In each case the procedure was to determine the general form and to adjust the constants or coefficients in terms of the observed data for 1869–1930 by the method of least squares. When the optimum formula or curves were determined, the average deviation from the observed records was computed, thus giving a relative measure of the success in fitting the formula to its basic data.

Among the well-known precipitation formulas followed were: (1) the reciprocal type, in which rainfall intensity is given by a suitable constant divided by the expression, duration in minutes plus another constant; (2) the exponential type, in which the denominator is the duration raised to a constant power; and (3) a modified exponential type, combining the better features of the others. This third formula has proved in every respect most satisfactory. Accordingly it is recommended not only for New York City, where it primarily applies, but also in principle, with the proper adjustment of detail, for other localities.

One of the important features of Mr. Bleich's paper is the comprehensive tabular data from the Central Park gage. This compilation is the fruit of exhaustive work, and gives the hydrologist an unusual opportunity for productive study. All in all, this paper may be expected to stimulate a generous interest in this subject of rainfall, upon which Society publications have been throwing light for many years.

INVESTIGATION OF WEB BUCKLING IN STEEL BEAMS

Since published scientific test data on the subject of web buckling in steel beams are very meager, the paper by Inge Lyse, Assoc. M. Am. Soc. C.E., is particularly important. The study is based on an investigation conducted at the John Fritz Laboratory at Lehigh University during 1933. A preliminary series of tests, involving four 12-in. 28-lb I-beams, was run to determine a method of approach to the problem. This was followed by what the author terms the major investigation—on two groups of five beams each. Group A consisted of three all-welded sections and two reinforced rolled sections. The beams in Group B were all welded and were whitewashed so that the spalling would indicate the lines of stress.



CONDITION OF A 22-IN. 62-LB I-BEAM, AT ULTIMATE LOAD
A Welded Beam Whitewashed to Make Lines of Stress Visible

The results of the investigation add rather definite knowledge concerning web behavior when the ratio of unsupported depth to thickness is less than the ratio at which genuine web buckling might be expected. The author concludes that the usefulness of a beam, as indicated by its yield-point strength, is determined by shearing stresses if the depth-to-thickness ratio is 70 or less.

ANNUAL REPORT OF THE BOARD OF DIRECTION

AS PRESENTED to the Annual Meeting on January 17, 1934, the full report of the Board of Direction concerning the Society's activities during 1933 and its financial status at the end of the year will be printed in the February issue of PROCEEDINGS. Highlights from the report have been abstracted and are presented elsewhere in these pages.

CLINE TABLES FOR SHARP-CRESTED WEIRS

THE PAPER by C. G. Cline, "Discharge Formulas and Tables for Sharp-Crested Suppressed Weirs," in the January PROCEEDINGS, contained tables in a condensed form to supply just enough information to make their general application clear. A limited number of photostatic sets of the complete tables are available at Headquarters for distribution at the nominal price of 50 cents per set of 15 tables.

News of Local Sections

CENTRAL ILLINOIS SECTION

At a meeting of the Central Illinois Section held on December 5, 1933, officers for the ensuing year were elected as follows: F. E. Richart, President, and R. P. Hoelscher, Secretary.

CENTRAL OHIO SECTION

There were 26 members and guests present at a luncheon meeting of the Central Ohio Section held in Columbus on December 14. After routine business matters had been attended to, the meeting was turned over to Mr. Lucks, Director of Public Service of Columbus, who described some of the difficulties encountered by city officials in the supervision of PWA and CWA projects.

CLEVELAND SECTION

The Cleveland Section, at its meeting held on December 7, 1933, elected the following officers for 1934: William Havens, President, and Louis K. Whitcomb, Jr., Secretary.

COLORADO SECTION

On November 20 the Colorado Section gave a dinner, followed by a meeting, at the Cosmopolitan Hotel in Denver. There were 118 members and guests in attendance at the dinner, and 284 at the meeting. A talk on the U. S. Bureau of Reclamation was given by R. J. Tipton, of Denver. Then four reels of motion pictures illustrating the construction of Boulder Dam were shown by E. B. Debler, Hydraulic Engineer for the U. S. Bureau of Reclamation. Another meeting of the Section was held at the Denver Athletic Club on December 18. The first speaker was George Begole, Mayor of the City of Denver, who commented on municipal affairs. He was followed on the program by Dr. Gustavson, Professor of Chemistry at the University of Denver, who spoke of recent achievements in the field of scientific research.

CONNECTICUT SECTION

A dinner meeting of the Connecticut Section was held at the Faculty Club in New Haven on December 11. In accordance with its annual custom, the Section had as its guests for the occasion senior class members of the Yale University Student Chapter. An illustrated lecture on the subject, "Rapid Transit Subways, New York City," was given by Robert Ridgway, Past-President of the Society and consulting engineer for the Board of Transportation, New York, N.Y. Brief talks were then given by Clarence Blakeslee, civil engineer and contractor of New Haven; Charles E. Smith, vice-president of the New York, New Haven and Hartford Railroad; and John C. Tracy, Professor of Civil Engineering at Yale University. A general discussion followed.

DAYTON SECTION

At its annual meeting held on December 18, 1933, the Dayton Section elected officers for the ensuing year as follows: Robert B. Prinz, President, and John F. Hale, Secretary.

GEORGIA SECTION

The Georgia Section of the Society held its regular monthly meeting on December 4. Included in the business session was the annual election of officers, which resulted as follows: George L. Reed, President, and R. P. Black and Olaf Otto, Vice-Presidents. The guest speaker was D. M. Therrell, who gave an interesting talk on the subject of the solar system.

INDIANA SECTION

The Indiana Section reports that its newly elected officers for 1934 are as follows: H. S. Morse, President, and W. A. Knapp, Secretary.

KANSAS CITY SECTION

There were several guests at the meeting of the Kansas City Section held at the University Club on December 11. Among these was Alonzo J. Hammond, then President of the Society, who addressed the gathering on the subject of Society affairs and the work of preparing a code for engineers. Other speakers were E. B. Black, consulting engineer of Kansas City, and J. F. Brown, Assistant Engineer for Black and Veatch, of Kansas City. The annual election of officers, which was held at this time, resulted as follows: Robert W. Waddell, President; Robert P. Woods, Vice-President; and C. S. Heritage, Secretary-Treasurer.

KANSAS STATE SECTION

A well-attended meeting of the Kansas State Section was held at Topeka on December 1. The president of the Section reported the appointment of a committee to study and report on salary and wage conditions as a basis for the formulation of the proposed engineers' code. A discussion on the subject of classifying engineers followed, and a report on the work of the U. S. Coast and Geodetic Survey in the employment of unemployed engineers in the State of Kansas was given. On January 11, 1934, a business meeting of the Section was held at Manhattan, Kans. During this session officers for the ensuing year were elected as follows: O. J. Eidmann, President; A. B. Griggs, Vice-President; and F. W. Epps, Secretary-Treasurer. There were 34 members and guests present.

LEHIGH VALLEY SECTION

Officers for the Lehigh Valley Section for 1934 have been elected as follows: H. G. Payrow, President, and M. O. Fuller, Secretary.

LOS ANGELES SECTION

A dinner meeting of the Los Angeles Section was held at the University Club on January 10, 1934. Numerous routine business matters occupied part of the session. Then E. C. Eaton, Chief Engineer of the Los Angeles County Flood Control District, gave an interesting talk on the subject of rainfall, especially in its application to local problems of flood control. He was followed by F. H. Hay, Chief Hydrographer for the Los Angeles County Flood Control District, who gave statistics on rainfall intensity and run-off. The other speakers were Edward Hyatt, State Engineer for the Division of Water Resources, and P. D. Nowell, secretary of the (California) State Water Plan Association. A general discussion from the floor followed these talks. There were 220 at the dinner, and approximately 250 at the meeting following it.

MARYLAND SECTION

At the annual meeting of the Maryland Section, held at the Engineers Club on December 7, officers for 1934 were elected as follows: J. Trueman Thompson, President; J. W. Armstrong, Vice-President; and Charles B. Bryant, Secretary-Treasurer. At the conclusion of the business session George T. Seabury, Secretary of the Society, gave a talk on some of the activities of the Society, with special reference to the difficulties encountered in the adoption of the proposed engineers' code and to conditions arising as a result of the present unemployment situation. After the meeting refreshments were served and a social hour enjoyed.

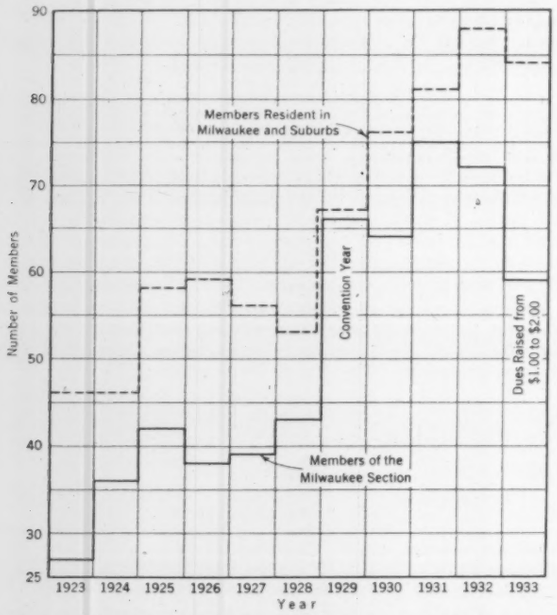
METROPOLITAN SECTION

A large and enthusiastic audience reported for the regular meeting of the Metropolitan Section, held in the Engineering Societies Building, in New York, N.Y., on January 10. After announcements, Charles P. Berkey, Professor of Geology at Columbia University, gave an illustrated talk on the subject, "Geologic Features of Certain Large Current Engineering Projects," drawing from his extensive experience on many prominent dam projects, including Boulder, Canyon, Pine Canyon, Grand Coulee, Owyhee, Cove Creek, and Madden. In his characteristically delightful manner, Dr. Berkey related experiences, pointed out geologic peculiarities, and diagnosed difficulties involved. About 300 members and guests enjoyed the meeting. Refreshments were served.

MILWAUKEE SECTION

On October 29, 1933, the Milwaukee Section held a meeting at the City Club. After various business matters had been attended to, the scheduled speaker of the evening, J. P. Gebhard, addressed the members on the subject, "Prequalification of Bidders on Contract Work." An enthusiastic discussion from the floor followed. A joint meeting of the Section and of the Marquette University

Student Chapter was held on December 13, with 38 members and guests in attendance. At the conclusion of the business session Charles Longenecker, Assistant Engineer of the Chain Belt Company, gave an illustrated talk on the subject, "The Use of 'Pumpcrete.'" The election of officers for 1934, which was held at this time, resulted as follows: R. W. Gamble, President; W. A. Peirce, First Vice-President; H. C. Webster, Second Vice-President; and F. W. Ullius, Secretary-Treasurer.



GROWTH OF MEMBERSHIP IN THE MILWAUKEE SECTION

NORTHWESTERN SECTION

The primary purpose of the meeting of the Northwestern Section held on December 14 was to discuss the status of survey work in the State of Minnesota. The principal speakers were A. S. Cutler, Professor of Railway Engineering at the University of Minnesota, and Hibbert M. Hill, of the U. S. Engineer Office, St. Paul, Minn.

PANAMA SECTION

At the annual meeting of the Panama Section the following officers were elected for 1934: E. S. Randolph, President; B. J Fletcher, First Vice-President; H. G. Arango, Second Vice-President; and L. B. Moore, Secretary-Treasurer. Following the business session, I. E. Burks, Chief Concrete Technician of the Madden Dam Division of the Panama Canal, gave a talk on the subject, "Concrete for Madden Dam."

PHILADELPHIA SECTION

On December 19 the Philadelphia Section held a joint meeting with the Engineers' Club. There were 136 present at the meeting and 53 at the dinner preceding it. The feature of the occasion was an illustrated address by Dexter S. Kimball, Dean of the College of Engineering of Cornell University, on the subject of the once great but now abandoned mines at Virginia City, Nev.

PUERTO RICO SECTION

The annual meeting of the Puerto Rico Section was held on December 12. The guest of honor was J. A. L. Waddell, consulting engineer of New York, N. Y., who delivered a lecture on vocational engineering. During the meeting officers for 1934 were elected, the results being as follows: A. C. Toll, President; Reinaldo Ramirez, Vice-President; and Antonio S. Romero, Secretary-Treasurer.

SAN DIEGO SECTION

The San Diego Section held a dinner meeting at the Churchill Hotel on November 23. The program consisted of brief talks by C. B. Meyer, R. L. Wing, and P. H. Van Etten, all engineers in the California State Division of Water Resources. They spoke, respectively, on methods of estimating water supplies, on flood control, and on the engineering features of the Central Valley Project.

At the annual meeting of the San Diego Section, held at the Churchill Hotel on December 28, the following officers were elected for the ensuing year: H. A. Noble, President; F. D. Pyle, Vice-President; and L. L. Mills, Secretary-Treasurer.

SAN FRANCISCO SECTION

There were 83 members and guests present at the regular meeting of the San Francisco Section held at the Engineers' Club on October 17. After a routine business session the speaker of the evening, Walter E. Packard, was introduced. Mr. Packard, who is an agricultural engineer, spoke on the subject, "Can Public Works Fill the Gap Created by the Slowing Down of Private Construction?" At the meeting of the Section held on December 19, the following officers were elected for 1934: N. A. Bowers, President, and Harold B. Hammill, Secretary-Treasurer.

ST. LOUIS SECTION

The St. Louis Section was host to senior class members of the Student Chapters at Washington University, Missouri University, and the Rolla School of Mines at a dinner given at the Engineers' Club on November 25. There were 78 present, 37 of this number being students. A talk on the ideals of the Society was given by F. G. Jonah, Chief Engineer of the Frisco Lines; and F. W. Green, Vice-President of the St. Louis Southwestern Railway Company, spoke on the subject, "What the Future Holds for the Graduate Engineer." The annual election of officers, which was held at this time, resulted as follows: W. J. Burton, President; H. Austill and S. C. Baker, Vice-Presidents; and R. A. Willis, Secretary-Treasurer.

UTAH SECTION

The Utah Section met at the University Club in Salt Lake City on the evening of November 16. An interesting statement of the progress of the public works program in Utah was presented by R. A. Hart, Federal Engineer for Utah for the PWA. Another interesting talk was given by Jacob Crane, temporarily in Salt Lake City for the Research Foundation, of New York, N.Y. He discussed his studies of the feasibility and possibilities of the proposed Great Salt Lake diking project, and then led an interesting discussion on advanced state planning.

Student Chapter News

NEW YORK UNIVERSITY

The New York University Student Chapter held a smoker on November 24. The speaker of the occasion was Charles Carswell, Assistant Engineer of the Port of New York Authority, who gave an interesting talk on the George Washington Bridge. Motion pictures were shown to illustrate his remarks. There was an attendance of 50.

RHODE ISLAND STATE COLLEGE

There were 43 present at a meeting of the Rhode Island State College Student Chapter held on December 6, 1933. The feature of the occasion was a talk by John H. Caton, who discussed information of use to young engineers. His remarks were based on his extensive experience in Central and Latin-American countries. At a meeting held on December 18, Gordon Roy, a student, delivered a paper on the subject of pavements.

UNIVERSITY OF PITTSBURGH

Frequent meetings have been held by the University of Pittsburgh Student Chapter during the autumn. On November 9 the members were addressed by Nathan Jacobs, vice-president and treasurer of Morris Knowles, Inc., of Pittsburgh. Various business matters were discussed at the meeting held on November 23. The speaker of the occasion was L. W. McIntyre, Traffic Engineer of the City of Pittsburgh, who spoke on problems connected with the operation of traffic lights.

ITEMS OF INTEREST

Engineering Events in Brief

CIVIL ENGINEERING for March

ABSTRACTS OF the papers and committee reports presented before the Annual Meeting, held at the Engineering Societies Building in New York, January 17–20, 1934, will entirely fill the March issue of CIVIL ENGINEERING. Of current interest was the paper presented under the auspices of the Engineering-Economics and Finance Division on a theory as to how Government ownership and operation of power utilities could be made practical. In an illustrated address on aerial photography, Capt. A. W. Stevens, U. S. Army, showed pictures taken from great heights with film sensitive to infra-red rays, on which mountain peaks 325 miles away appeared, even though they were obscured from normal vision by haze or mist. An article giving the main points of his address is in preparation.

At the sessions of the Technical Divisions on Thursday many subjects of interest were presented. That of national planning held the attention of the City Planning Division, which listened to papers explaining how nation-wide plans, if available, could help in the proper expenditure of emergency relief funds; how the most useful development of the major highway net could result only from a nation-wide plan; and how the Nation's transportation facilities could better serve the country by being coordinated so that each would perform that service for which it was best adapted. An experiment in Government control and operation of hydro-electric power in the Tennessee Valley formed the subject of another address.

At the session of the Construction Division, the functions of the construction engineer were viewed from both the engineer's and the contractor's standpoint. Construction engineering on emergency public works in Missouri also formed the basis of an enlightening presentation. At the session of the Sanitary Engineering Division the subjects of the behavior of water passing through sand and the corrosion of metals buried underground brought out lively discussion. The effect on traffic movement of two recently completed highway structures in New York—the West Side Elevated Highway and the Holland Tunnel—was explained in two papers read before the Highway Division. A paper given before the Waterways Division emphasized the necessity for verifying in the field the results of hydraulic laboratory tests on models, and another dealt with the movement of sand along seacoasts.

At the session of the Structural Division unusual interest was manifested in the papers on light-weight bridge floors for increasing the capacity of existing bridges and reducing the cost of new ones. Abstracts of these papers are also being prepared for inclusion in the March issue of CIVIL ENGINEERING.

The Wind in Literature

By ROBINS FLEMING

AMERICAN BRIDGE COMPANY, NEW YORK, N.Y.

WEARY WITH the study of wind stresses in engineering structures, especially those in many-storied buildings, the structural engineer could find a delightful change of thought if he would turn to the wind as portrayed in literature.

To begin with the Hebrew Scriptures, near the very beginning he will find the commonly rendered "cool of the day" (Genesis 3:8) is given in the margin as "wind of the day." More than once is found the poetic expression, "wings of the wind." The author of Ecclesiastes must have been a close observer of nature, for he writes: "The wind goeth toward the south, and turneth about unto the north; it turneth about continually in its course, and the wind returneth again to its circuits."

GRECIAN NAMES FOR THE WINDS

The Athenians gave names to their winds. In Athens, near the Acropolis, there is standing a small temple whose walls were built 22 centuries ago. It is known as the Tower of the Winds. The allegorical figures on the frieze of the tower represented the characteristics of the weather as the wind blew from each of the eight cardinal directions. They were: Boreas, the north wind; Kaikias, the northeast wind; Apheliotes, the east wind; Euros, the southeast wind; Notos, the south wind; Lips, the southwest wind; Zephyros, the west wind; and Skiron, the northwest wind. (Professor McAdie in his book, *Wind and Weather*, gives reproductions of the eight bas-reliefs in the library of the Blue Hill Observatory which were copied from the frieze of this tower.)

Roger Ascham (1515–1568), the tutor of Queen Elizabeth, claimed he actually saw the wind. In his *Toxophilus* he writes, "To see the wind with a man's eyes it is impossible, the nature of it is so fine and subtle, yet this experience of the wind had I once myself, and that was in the great snow which fell four years ago." Old Roger gives a detailed description of what he saw ("Arber English Reprints," Vol. 3).

It was because of a terrible storm that ravaged the West Indies in August 1772 that Alexander Hamilton was brought into American history. Born in the little island of Nevis, a British possession, most of his youth was spent in the island of St. Croix, a Danish possession. Not yet 16, he wrote a description of the storm before its terrors had worn off and while its effects were still visible. This was printed in *The Royal Danish-American Gazette*, Christianstadt, St. Croix, issue of October 3, 1772. Such was the impression it made at St. Croix that the Governor and some of the principal persons made an effort to discover its author and ultimately traced it to Hamilton. "This simple incident decided his fate. His wishes were consulted, and it was determined to send him to New York to complete his education." (*The Life of Alexander Hamilton*, by his son, John C. Hamilton, Vol. 1, page 6.)

Incidentally it may be mentioned that a hurricane and earthquake delayed for 50 years the acquisition of the Virgin Islands by the United States. A treaty was signed in Copenhagen, October 24, 1867, ceding the islands of St. Thomas and St. John to the United States. The treaty, however, was not ratified by the United States Senate. In November 1867, a hurricane accompanied by an earthquake visited St. Thomas, inflicting great damage upon the shipping as well as upon the town. In the inflamed state of the public mind it was seized upon for political effect. Should public money be thrown away on buying earthquakes and cyclones?

"Mr. Seward's treaty, however, being destined to encounter every possible mishap, both the earthquake and the hurricane of 1867 must needs be violent beyond any previous examples" (*The Danish Islands*, Parton).

DESCRIPTIONS IN LITERATURE

In this connection may be mentioned the thrilling descriptions of the force of the wind in storms at sea as told by Joseph Conrad in his sea tales, notably in *Typhoon*. One observation will be quoted:

"This is the disintegrating power of a great wind, it isolates one from one's kind. An earthquake, a landslip, an avalanche, overtake a man immediately, as it were without passion. A furious gale attacks him like a personal enemy, tries to grasp his limbs, fastens upon his mind, seeks to rout his very spirit out of him."

One of the peculiarities of the tropical cyclone is the calm area at the center, "the hole at the center of the hurricane doughnut," known as "the eye of the storm." Tennyson calls it "the whirlwind's heart of peace" ("The Voyage").

Milton in "L'Allegro" gracefully alludes to "the frolic wind, that breathes the spring."

ALLUSIONS IN SHAKESPEARE

It is not surprising to find in Shakespeare, who drew so largely from nature, more than two hundred allusions to the wind.

"Wind-changing Warwick now can change no more" (*Henry VI*, Part III).

"When the sweet wind did gently kiss the trees," (*The Merchant of Venice*).

"For vice repeated is like the wandering wind,
Blows dust in others eyes, to spread itself" (*Pericles*).

". . . . , but when the splitting wind
Makes flexible the knees of knotted oaks" (*Troilus and Cressida*).

"No, believe me, 'tis very cold, the wind is northerly" (*Hamlet*).

Shelley's "Ode to the West Wind" is a classic.

Dickens has one of his characters say, "I am always conscious of an uncomfortable sensation now and then when the wind is blowing in the east" (*Bleak House*).

George Eliot writes, "But certain winds will make men's tempers bad" (*The Spanish Gypsy*).

No anthology of the wind would be complete that did not include Emerson. He uses many adjectives in describing a wind. "The pious wind" (*The Poet*); "the prophetic wind" (*Woodnotes*); "a forgetting wind" (*Uriel*); "the icy wind" (*May-Day*); "Bitter winds and fasts austere" (*Monadnoc*), are some of them.

The foregoing does not pretend to treat the large subject of the wind in literature but merely to give a few observations on it. The engineer may assert that this is the region of fancy and has nothing to do with the hard facts of physical science. Let it be remembered that in the reams of paper that have been written on wind stresses the region of fancy has also been entered. A great amount of conjecture has been based upon a small amount of fact.

Introduction of Railroads In England

OVER A hundred years ago, in the December 19, 1829, issue of the daily, *Shipping and Commercial List and New York Price Current*, appeared the following quotation, introduced by the editor as an "extract of a letter from W. Brown, Esq., received in Baltimore per the *William Byrnes*, dated Liverpool, November 6, 1829." This letter sets forth clearly the feeling in England occasioned by the introduction of the steam locomotive for railroad operation.

"Mr. Winans and Geo. A. Brown have just returned from Rain Hill, about 12 miles from this city, on the Liverpool and Manchester Rail-road, where they have been amusing themselves riding on Mr. Stevenson's Locomotive Engine, at the rate of *twenty-eight miles an hour*—drawing about thirty passengers. She is represented to have gone one mile in a minute and sixteen seconds! (about forty miles an hour!) but this Mr. Stevenson himself can scarcely credit. She drew forty-two tons, on a level road, fifteen miles per hour. New Rail-roads are projecting all over the country—a meeting is to be held on Wednesday to create a company to carry one to Birmingham. Canal property is ruined. I believe the Sanky has fallen from 1,800£ per share to 600£. In fact they are even anticipating that it may be necessary to let the canals dry, and to lay rails on them. The canal property in this country has cost about thirty millions of pounds sterling—its length about 2,600."

It is interesting to note that the railroads, which originally won out in competion with the canals, are themselves now feeling the effects of still more modern forms of transportation.

Submitted by Frank B. Tucker, Assoc. M. Am. Soc. C.E.

An Engineer's Non-Technical Obligations

Extracts from an address by F. W. Green, M. Am. Soc. C.E., delivered at the annual meeting of the St. Louis Section of the Society in November 1933, at which students from the neighboring universities were guests of the Section.

EACH GENERATION has its problems—those which it inherits unsolved from the previous generation and those which it creates itself and passes unsolved to the succeeding generation. As the potential strength of an electric current is measured by the resistance it passes through, so is a man measured by the difficulties he can overcome. A successful man conquers his problems—the failures succumb to them.

A few years ago in a Chicago club one Sunday evening, a discussion occurred in a group of 27 men, all of them college graduates, ranging from 23 to 67 years of age, and from some 14 different colleges or universities. The subject was: Since obtaining your degree, excluding degrees in law, medicine, dentistry, architecture, engineering, and similar purely professional degrees, what in order of importance were the major benefits to you in your business life which may directly be credited to your college education? The answers were: first, the acquirement and development of the social graces, that is, the ability to make smooth and easy contacts with all kinds of people under all kinds of conditions; second, the development of the critical faculty, that is, ability critically to appraise facts—to distinguish the truth from error; and third, a knowledge of how intelligently to use books and how to search and find any needed information.

In the past the engineer accomplished wonders in making enormous contributions to our national development. Our frontiers would never have been pushed so far back into the hinterland without him. So rich were the prizes of frontier exploitation that refinements of almost every nature were ignored. These men had never heard of differentials of the second and higher orders, yet this did not deter them from ignoring them as you would ordinarily very properly do. But they ignored many other things which you, with your richer educational advantages, would not. These men wasted very little time on refinements of design—they just used a large factor of safety and let it go at that. These things can hardly be done that way in the future. The present-day demand is too insistent for the greatest capacity for the fewest dollars, and this means resort to prismoidal formulas, the method of least squares, mass diagrams, the method of least work, frequency curve distribution, and similar technique, which many of this older generation never heard of, or if they did, they would denounce with vituperative expectoration.

In the future the engineer will have to be something much more than he has been in the past. To be successful and to play the very important part he is destined to play, he must be something more than an instrumentman, draftsman, designer, estimator, and superintendent of construction or of maintenance. He will have to do as our European brethern have had to do—develop a wider and deeper cultural and technical background. He must not only know what he knows, but he must have the ability to make the non-professional groups understand it. He must learn how to speak and write English. He must understand enough of accounting to discuss intelligently with accountants and business men the accounting aspects of his engineering problems. He must understand enough of finance and banking routine to convince the man that furnishes the money for his projects that he can be entrusted with its disbursement. He must know enough of economics to avoid the too frequent error of beautiful plans for projects which will not be self-liquidating.

Nothing is more disastrous to any engineer than to be right about his engineering technique but wrong about his business "horse sense." No amount of education will ever compensate for a lack of common sense, or for a lack of the fundamental necessary traits of human character, namely, honesty, loyalty, dependability, resourcefulness, capacity for team work, perseverance, and leadership. With these there can be no doubt that the engineer of tomorrow will make good in a large way, and in many lines of human endeavor outside of strictly engineering industries.

NEWS OF ENGINEERS

From Correspondence and Society Files

R. W. STILES has accepted a position as Resident Engineer with the Texas State Highway Department. His headquarters will be Santa Anna, Tex.

THEODORE A. BEYER has resigned as vice-president of James J. Burke and Company, Inc., of Salt Lake City, Utah, to become president of the Theodore A. Beyer Corporation, general building contractors of Los Angeles, Calif.

O. B. BESTOR has accepted an appointment as Engineer of Permanent Surveys and Records with the North Carolina State Highway and Public Works Commission. His office is in Raleigh, N.C.

EARL L. HAGEMAN has now become Associate Engineer in the Department of Public Works of the 14th Naval District, with headquarters in Honolulu, Hawaii.

GEORGE E. GOODALL, who was formerly Senior Engineer in the Division of Water Resources of the California State Department of Public Works, is now associated with the U. S. Engineer Department in the capacity of engineer. His headquarters will be Sacramento, Calif.

BROWN C. TINEY has resigned his position as Maintenance Engineer in the Michigan State Highway Department to accept an engineering connection with the Calcium Chloride Association, of Detroit, Mich.

CLIFFORD C. NEWSOM, formerly District Engineer for the Indiana State Highway Commission, is now Associate Highway Engineer in the U.S. Bureau of Public Roads, with headquarters in Macon, Ga.

ARTHUR F. PILLSBURY has accepted a position as Assistant Conservationist in the California Forest Experiment Station of the U.S. Forest Service. His office is in Berkeley, Calif.

S. I. ZACK is now engaged as Sanitary Engineer by the Filtration Equipment Corporation, of New York, N.Y., a subsidiary of the American Cyanamid Company. Previously he was associate editor of *Water Works and Sewerage*.

FREDERICK H. POND has resigned as Assistant Engineer for the Board of Estimate and Apportionment of New York, N.Y., to accept a position in a similar capacity in the Office of the Director of the Budget of the same city.

OLAF LAURGAARD, formerly City Engineer of Portland, Ore., has established a consulting civil engineering practice in that city. He will specialize in municipal, hydraulic, and highway engineering.

CHARLES L. HILL has resigned his position with the Nevada Rock and Sand Company, Inc., to rejoin the staff of the State of Nevada Department of Highways in the capacity of resident engineer on highway construction.

RUSSELL WOODBURN has accepted a position as Camp Engineer in the Kentucky Forest Service, with headquarters at Camp Hall, Dixon, Ky.

JOHN E. BOMAR has accepted a connection with Charles E. Lund and Associates, engineers, on the construction of a causeway across Old Tampa Bay, at Tampa, Fla.

KENNETH W. PREST, formerly with the Standard Dredging Company, of New York, N.Y., has taken a position in the Hillsborough County (Florida) Engineering Department, with headquarters in Tampa.

JAMES S. LEWIS, JR., has resigned as Construction Engineer for the Virginia Public Service Company to become Assistant Designing Engineer with the Tennessee Valley Authority, at Knoxville, Tenn.

C. F. WASSER has resigned as Resident Engineer for the Georgia State Highway Department to accept an appointment as Assistant Highway Engineer in the U.S. Forest Service, with headquarters in Dahlonega, Ga.

L. C. PARKS is now a senior draftsman in the U.S. Engineer Office. He is stationed at Glasgow, Mont., where he is employed on the Fort Peck Dam Project.

ROSS M. RIEGEL has accepted an engineering connection with the Tennessee Valley Authority. His offices will be in Knoxville, Tenn.

LEO M. ARMS, who was formerly Chief Engineer for the American Concrete Marbelite Company, of Chicago, Ill., has taken a position as Highway Engineer with the Highways and Municipal Bureau of the Portland Cement Association, with headquarters in the same city.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From December 10, 1933 to January 9, 1934, Inclusive

ADDITIONS TO MEMBERSHIP

ADAMSON, ARTHUR (Jun. '33), 305 East 78th St., New York, N.Y.

ANDERSON, JAMES DONALD (Jun. '33), Oil Insp., State Highway Dept., Pine Bluff, Wyo.

ANTHONY, THOMAS CRAWSHAW, JR. (Jun. '33), 10 Los Roble Court, Pennside, Reading, Pa.

ANTROBIUS, GEORGE JOHN (Jun. '33), 718 North 23d St., East St. Louis, Ill.

ARMENTROUT, WILLIAM FRANCIS (Jun. '33), Waynesboro, Va.

BALABAN, MORTON LIONEL (Jun. '33), 669 Myrtle Ave., Brooklyn, N.Y.

BALDRIDGE, WILSON DWIGHT (Jun. '33), Parma, Idaho.

BALDWIN, WILLARD JUSTUS (Jun. '33), Box 254, Colebrook, N.H.

BARCLAY, GEORGE EDWARD (Jun. '33), 104 North Overland, Burley, Idaho.

BARENFANGER, LEWIS EDWARD (Jun. '33), County Supt. of Highways, Salem, Ill.

BAUKNIGHT, WILFRED (Jun. '33), Box 31, Sebree, Ky.

BENSCHEIDT, ADOLPH (Jun. '33), 219 Fifth Ave., West, Eugene, Ore.

BLANK, WILLIAM ALVIN (Jun. '33), 710 South Broadway, Albuquerque, N.Mex.

BOONE, HARRY KAY (Assoc. M. '33), With Federal Administration of Public Works; 6261 Olympic Boulevard, Los Angeles, Calif.

BOYD, ALFRED (M. '33), Prof., Civ. Eng., Univ. of North Dakota, University Station, Grand Forks, N.Dak.

BRADY, KENNETH (Jun. '33), Box 110, Huntsville, Tex.

BRENNAN, WILLIAM ANDERSON (Assoc. M. '33), Deputy Commr. of Public Safety (Res., 3 Saxon Woods Park Drive), White Plains, N.Y.

BRENNEKE, AUGUSTUS MARTIN (Assoc. M. '33), City Engr. (Res., 1201 West Walker St.), Denison, Tex.

CARPENTER, EDWARD LARAMIE, JR. (Assoc. M. '33), 601 Coronado Ave., Long Beach, Calif.

CARSTENSEN, HERMAN CHARLES (Assoc. M. '33), Bridge Engr., Wood County, County Surveyors Office, Bowling Green, Ohio.

CARTER, GEORGE RICHMOND (Jun. '33), C.C.C. Camp 54-E, Du Quoin, Ill.

CLINTON, ROBERT (Jun. '33), 43 Wyman Rd., Braintree, Mass.

CONWELL, JAMES ALEXANDER (Jun. '33), 3669 Indiana St., San Diego, Calif.

COTTON, JOHN CASKEY (Jun. '33), Engr., U.S. Dept. of Agriculture, Animal Husbandry Farm, Beltsville, Md.

CRAWFORD, GLENN ARTHUR (Jun. '33), City Engr. (Res., 239 Italia St.), Covina, Calif.

CROWE, GEORGE FREDERICK (Jun. '33), 4548 Eleventh Ave., N.E., Seattle, Wash.

DANIELS, FRANK EDWARD (Jun. '33), 144 Clinton Ave., Bridgeport, Conn.

DAVIDSON, ARTHUR JEROME (Jun. '33), 1107 Logan St., Moscow, Idaho.

DAVIES, NORMAN OWEN (Jun. '33), 6310 Nineteenth Ave., N.E., Seattle, Wash.

DE HART, STANLEY BURSON (Jun. '33), Company 1217, Ricker Mills, Vt.

DEMERITT, GEORGE WESLEY (Jun. '33), 86-15 Fifty-fourth Ave., Elmhurst, N.Y.

DE MILITA, JOSEPH (Jun. '33), 1431 West 37th Drive, Los Angeles, Calif.

DICKSON, RONALD (Assoc. M. '33), Care, Harbor Engr., Port Elizabeth, Union of South Africa.

DIGENNARO, JOHN ANTHONY (Jun. '33), 68 West 56th St., Bayonne, N.J.

ECKELMEYER, ALBERT FREDERICK (Jun. '33), 4332 North Carlisle St., Philadelphia, Pa.

EKLOFF, EDWIN EMANUEL (Jun. '33), 30 High St., Croton-on-Hudson, N.Y.

ENGMAN, NORRIS VICTOR (Jun. '33), 714 Washington Ave., Terre Haute, Ind.

FEHRER, JOHN NICHOLAS (Jun. '33), 2654 Harford Ave., Baltimore, Md.

FERNALD, GORDON HILDRETH, JR. (Jun. '33), 1185 Pine St., San Francisco, Calif.

FERNÁNDEZ CASADO, CARLOS (Assoc. M. '33), Cons. Engr., Plaza Alonso Martinez 5, Madrid, Spain.

FLACK, WILLIAM REITZ (Assoc. M. '33), Res. Engr., State Dept. of Highways (Res., 213 West Homestead St.), Medina, Ohio.

FLOYD, WESLEY RUFUS (Jun. '33), R. F. D. 1, Amesbury, Mass.

FRY, JOSEPH ELMER, JR. (Jun. '33), Rodman, James Stewart Co., Inc. (Res., 5 West 63d St.), New York, N.Y.

GARBARINI, EDGAR JOSEPH (Jun. '33), 2713 Coolidge Ave., Oakland, Calif.

GARDNER, LEIGH OWEN (Jun. '33), 903 Smith St. Miami, Ariz.

GIBSON, OTEN CLAY, JR. (Jun. '33), 333 Oak St., Norton, Va.

GITTLESON, IRVIN (Jun. '33), Draftsman, Waddell & Hardesty, 142 Maiden Lane (Res., 2825 Webb Ave.), New York, N.Y.

GOULD, JACK HUMPHREY (Jun. '33), Engr. Examiner, Civil Works Administration, 307 South 5th St., Louisville, Ky.

GUMENSKY, DMITRY BENJAMEN (Assoc. M. '33), Care, Met. Water Dist. of Southern California, 306 West 3d St., Los Angeles, Calif.

HAUBER, FERDINAND RICHARD (Jun. '33), Junior Structural Engr., Dept. of Public Works, Div. of Highways (Res., 3067 Lischer Ave.), Cincinnati, Ohio.

HICKS, GARDNER WORDELL (Jun. '33), 187 Main St., Tiverton, R.I.

HOLLERAN, LESLIE GILBERT, JR. (Jun. '33), 3 Lincoln Circle, Crestwood, N.Y.

HOLZER, ERNEST (Assoc. M. '33), 1065 Woodycrest Ave., New York, N.Y.

HOWELL, JOHN TUDHOPE (Jun. '33), With Pacific Gas & Elec. Co., Oakland (Res., 2425 Ellsworth St., Berkeley), Calif.

IRVINE, JAMES OSBORNE (Jun. '33), Salesman, National Cash Register Co., 205 East 42d St., New York, N.Y. (Res., 111 Garrison Ave., Jersey City, N.J.)

JAGOW, ARNOLD WILLIAM (Jun. '33), General Delivery, Stanford University, Calif.

JOHNSON, ROBERT KINNAIRD (Assoc. M. '33), Agt., The Northwestern Mutual Life Insurance Co.; 1033 Quincy St., Parkersburg, W.Va.

KAMY, HARRY DONALD (Jun. '33), 3511 Putnam Pl., New York, N.Y.

LAMANNO, EMANUEL SALVATORE (Jun. '33), 4270 Park Ave., New York, N.Y.

LEIGHTON, CHARLES KELTON (Jun. '33), Care, State Highway Dept., Box 1154, Borger, Tex.

LEROY, JAMES MILTON (Jun. '33), Box 274, Windsor, N.C.

LEWIS, PERLEY MITCHELL (Assoc. M. '33), Engr. and Contr. (Lewis Brothers), (Res., 2946 North 3d St.), Phoenix, Ariz.

MCALEER, JOHN BERNARD (Jun. '33), 50 Grand View Rd., North Weymouth, Mass.

MCGILVRA, ROBERT DICKINSON (Jun. '33), 1527 South East 47th Ave., Portland, Ore.

MADDOX, EDWARD FINNIN (Assoc. M. '33), Res. Engr., State Highway Dept., Kerrville, Tex.

MAHON, JUSTIN DAVID (Jun. '33), 304 Woodlawn Ave., Jersey City, N.J.

MAIER, LOUIS HERMAN, JR. (Jun. '33), 6 Boston Post Rd., New Rochelle, N.Y.

MARDUS, FREDERICK (Assoc. M. '33), Designing Engr., F. A. Swertz, 49 West 45th St., New York (Res., 221 Ward Ave., St. George), N.Y.

MAST, FREDERICK WILLIAM (Jun. '33), 2320 Jefferson St., Quincy, Ill.

MERCER, GLEN LUDLOW (Assoc. M. '33), Asst. Engr., Office of Chf. Engr., Western Lines, A. T. & S. F. Ry. (Res., 1202 West 10th Ave.), Amarillo, Tex.

METZGER, JOHN JOSEPH, JR. (Jun. '33), Engr., Jefferson Lake Oil Co., Inc., Box 457, New Iberia, La.

MILLIGAN, CLEVE HENRY (Jun. '33), 2562 Adams St., Ogden, Utah.

MITCHELL, PARK, JR. (Jun. '33), 6501 Bustleton Ave., Philadelphia, Pa.

MORTENSEN, CLIFFORD NELSE (Jun. '33), 11008 Third St., N.W., Seattle, Wash.

MORTON, CHARLES MOREHEAD (Jun. '33), Surv., Hays County, Box 217, San Marcos, Tex.

NEWMAN, EDWIN MAHLON (Jun. '33), La Crosse, Kans.

NOBES, CHARLES WILLIAM (Jun. '33), 457 South Jackson St., Frankfort, Ind.

NYE, HOWARD BOYD (Jun. '33), Adams Center, N.Y.

PATTERSON, EDHAR LLEWELLYN (Jun. '33), Care, Dr. Stevenson, Everett Rd., Red Bank, N.J.

PLATT, HOWARD CHARLES (Assoc. M. '33), 209 Hutton St., Jersey City, N.J.

RAMIREZ, FRANK MILTON (Jun. '33), Box 627, Mayaguez, Puerto Rico.

ROESEL, ERWIN JOSEPH (Jun. '33), Denny and Chester Aves., Kirkwood, Mo.

RUSH, BENJAMIN FRANKLIN (M. '33), Chf. Engr., Dept. of Public Works, City and County of Honolulu (Res., 2930 Park St.), Honolulu, Hawaii.

RUSSELL, FRANK MCKLVEEN (Jun. '33), 937 Fifteenth St., Boulder, Colo.

RYDER, LINCOLN WOODBURY (Jun. '33), 79 Winthrop Ave., Wollaston, Mass.

SCRIVENS, WALTER AMBROSE, JR. (Jun. '33), 180 Poplar Ave., Hackensack, N.J.

SEARCH, CHARLES OSCAR (Jun. '33), Box 96, Fort Montgomery, N.Y.

STEWART, JOHN A. (Jun. '33), 82 Oak St., Jersey City, N.J.

STITES, HOWARD INGHAM (Assoc. M. '33), City Engr. (Res., 1066 North Angeleno Ave.), Burbank, Calif.

SUMWALT, ROBERT LLEWELLYN (M. '33), Prof., Civ. Eng., Univ. of South Carolina (Res., 1624 College St.), Columbia, S.C.

SUTHERLAND, JOHN GORDON (Jun. '33), Div. Engr's. Office, C. P. Ry., Sudbury, Ont., Canada.

TATUM, FRED ERWIN (Jun. '33), Nora Springs, Iowa.

THOMAS, ALBERT COOKE (Jun. '33), 501 Wildwood Parkway, Baltimore, Md.

THOMAS, CYRIL (Jun. '33), 2626 J St., Sacramento, Calif.

THURBER, PAUL (Jun. '33), Instr., Eng. and Math., Murray State School of Agriculture, Tishomingo, Okla.

TIEDEMAN, FREDERIC WILLIAM (Jun. '33), 325 East 16th St., Brooklyn, N.Y.

TUCKER, JOHN THOMAS (Jun. '31), 3733 Spruce St., Philadelphia, Pa.

VAN LIEW, ROSCOE EMERSON (Jun. '33), 155 Second Ave., Salt Lake City, Utah.

VILLEPIQUE, ARTHUR GRANT (Jun. '33), 20 Bedford Pl., Glen Rock, N.J.

WAHL, GEORGE RENE ROBERT (Jun. '33), 34 Navesink Ave., East Keansburg, N.J.

WANDMACHER, FREDERICK CORNELIUS, JR. (Jun. '33), 1290 New York Ave., Brooklyn, N.Y.

WATTS, CLEAL THOMAS (Assoc. M. '33), 721 Euclid Ave., Des Moines, Iowa.

WEINBERG, LOUIS DAVID (Jun. '33), 18 South Burnham Ave., Lansing, Ill.

WEINBERGER, SAMUEL AARON (Jun. '33), 2446 University Ave., New York, N.Y.

WHITE, GEORGE CLIFFORD (Jun. '33), Care, U. S. Coast and Geodetic Survey, Box 1132, Stockton, Calif.

WHITEHEAD, ROBERT LEE (Assoc. M. '33), Res. Engr., State Highway Comm., Box 115, Enfield, N.C.

WITMER, EARL JOHN (Jun '33), 1217 North 2d St., Harrisburg, Pa.

WITZIGMAN, FREDERICK SCOTT (Jun. '33), Surveyman, U. S. War Dept., Corps of Engrs. (Res., 617 Rundell), Iowa City, Iowa.

WOOD, ROBERT HART (Jun. '33), Structural Draftsman and Estimator, Bridge Div., State Highway Dept. (Res., 520 North St.), Jackson, Miss.

MEMBERSHIP TRANSFERS

ANDERSON, MARSHALL PATTON (Jun. '24; Assoc. M. '32), Care, Tennessee Val. Authority, Knoxville, Tenn.

ASH, CHARLES (Assoc. M. '28; M. '33), Res. Engr. Insp., Public Works Administration, Springfield (Res., 330 South Charles St., Lima), Ohio.

BATES, FRANCIS (Assoc. M. '17; M. '33), Cons. Engr., 503 Bradbury Bldg., Los Angeles, Calif.

ERWIN, FRANK JACKSON (Jun. '27; Assoc. M. '33), Asst. Structural Engr., Procurement Div., U.S. Treasury Dept. (Res., 3519 Thirteenth St., N.W., Apartment 204), Washington, D.C.

HALLORAN, PAUL JAMES (Assoc. M. '27; M. '33), Lieut., C.E.C., U.S.N., Public Works Officer, Marine Barracks, Quantico, Va.

LEWIS, JAMES SPENCER, JR. (June '26; Assoc. M. '33), Asst. Designing Engr., Tennessee Val. Authority, Box 1584, Knoxville, Tenn.

MCKEAGUE, EDWARD DANIEL (Jun. '28; Assoc. M. '33), Designer, Standard Oil Co. (Indiana), Whiting, Ind. (Res., 9232 Woodlawn Ave., Chicago, Ill.)

MCKEAN, HARRY PARKER (Jun. '11; Assoc. M. '18; M. '33), Civ. Engr., Harza Eng. Co., 20 North Wacker Drive, Chicago, Ill.

MATTHEW, RAYMOND (Jun. '16; Assoc. M. '21; M. '33), Superv. Hydr. Engr., Div. of Water Resources, State Dept. of Public Works (Res., 1515 Tenth St.), Sacramento, Calif.

MOCKMORE, CHARLES ARTHUR (Assoc. M. '28; M. '33), Prof. and Acting Head, Dept. of Civ. Eng., Oregon State Coll. (Res., 962 Van Buren St.), Corvallis, Ore.

RAUH, CHARLES EDWARD, JR., (Jun. '23; Assoc. M. '33), Engr., Western Elec. Co., New York, N.Y. (Res., 198 James St., Bogota, N.J.)

ROSENBERG, HERMAN HARRIS (Jun. '28; Assoc. M. '33), Engr. for David Goldberg (Res., Carroll Apartments, Lenox St.), Uniontown, Pa.

SAMSON, WALTER HOWARD (Jun. '29; Assoc. M. '33), Engr., Board of Water Supply (Res., 2610 Halelena St.), Honolulu, Hawaii.

WEED, ELLSWORTH SAMUEL (Jun. '26; Assoc. M. '33), Asst. Engr., Water and Power Resources Board, Harrisburg (Res., 410 Fifteenth St., New Cumberland), Pa.

REINSTATEMENTS

WOODELTON, GEORGE OSBORNE, Affiliate, reinstated Dec. 27, 1933.

RESIGNATIONS

BAILEY, THERON PIERCE, Jun., resigned Dec. 28, 1933.

BENHAM, CHARLES, JR., Assoc. M., resigned Dec. 14, 1933.

BOWLES, JAMES TEN BROECK, Affiliate, resigned Dec. 11, 1933.

BROWN, HENRY GASSAWAY, JR., Jun., resigned Jan. 8, 1934.

BRUA, ELMER GEORGE, Assoc. M., resigned Dec. 26, 1933.

BUYS, CORNELIUS KOUWENHOVEN, Jun., resigned Dec. 18, 1933.

CHRISTHILF, FRANCIS DORSEY, Assoc. M., resigned Dec. 12, 1933.

CONVERSE, WARREN HOOVER, JR., Assoc. M., resigned Dec. 19, 1933.

CUMMINS, CHARLES ALBERT, Assoc. M., resigned Dec. 18, 1933.

DODGE, KEITH LAMAR, Jun., resigned Dec. 29, 1933.

DOMBART, WILBUR BRUCE, Jun., resigned Dec. 11, 1933.

ENEARL, FRANK ALLAN, Jun., resigned Dec. 13, 1933.

EVANS, WILLIAM HAROLD, Assoc. M., resigned Dec. 27, 1933.

GRUT, RYAN ASGER, Assoc. M., resigned Dec. 12, 1933.

HARMAN, JOHN JAMES, M., resigned Dec. 26, 1933.

KRICK, DANIEL HIGH, Jun., resigned Dec. 12, 1933.

LANGE, WILLIAM HERBERT, Assoc. M., resigned Dec. 26, 1933.

LEWIS, CARLTON HYLER, Jun., resigned Dec. 26, 1933.

LYFORD, OLIVER SMITH, M., resigned Dec. 29, 1933.

LYON, RICHARD BONHAM, Jun., resigned Dec. 15, 1933.

MACALLUM, ANDREW FULLERTON, M., resigned Dec. 11, 1933.

MCCOY, CHARLES EPHRAIM, M., resigned Dec. 26, 1933.

MEANS, JOHN SIEMON, M., resigned Dec. 8, 1933.

MEEHAN, WILLIAM, Jun., resigned Dec. 12, 1933.

MELTZER, FRED CARL, Jun., resigned Jan. 5, 1934.

MILLER, PAUL BERTOLET, Assoc. M., resigned Dec. 27, 1933.

MILLER, SAMUEL FISHER, Affiliate, resigned Dec. 26, 1933.

MILLSPAUGH, FRANCIS CORWIN, Assoc. M., resigned Dec. 27, 1933.

MITCHELL, HARLAN MARKS, M., resigned Dec. 18, 1933.

MONIWA, CHUJIRO, M., resigned Dec. 14, 1933.

MOWER, LOWELL KENDALL, Jun., resigned Dec. 8, 1933.

OLSON, WILLARD MARTIN, Assoc. M., resigned Dec. 27, 1933.

ORR, ERNEST IRVING, Jun., resigned Dec. 27, 1933.

OVERSHINER, WILLIAM HUMPHREYS, Assoc. M., resigned Jan. 4, 1934.

PETERSON, LOUIS BERTIL, Jun., resigned Jan. 4, 1934.

PRETTYMAN, EDWARD, Assoc. M., resigned Jan. 4, 1934.

ROBERTS, HAROLD WHITNEY, Assoc. M., resigned Dec. 13, 1933.

RUSSUM, THOMAS FRENCH, M., resigned Jan. 4, 1934.

SCHWARTZ, MORRIS LOUIS, Assoc. M., resigned Dec. 31, 1933.

SHIPLEY, HENRY FRANKLIN, M., resigned Jan. 8, 1934.

SLAVIN, HARRY WILLIAMS, Assoc. M., resigned Dec. 26, 1933.

STEARNS, FRED LEROY, Assoc. M., resigned Dec. 19, 1933.

STOCKER, DWIGHT LATHROP, Jun., resigned Dec. 8, 1933.

STOLL, ALFRED PHILLIP, Jun., resigned Jan. 4, 1934.

TARBELL, HAROLD LEON, Jun., resigned Dec. 29, 1933.

TAYLOR, RUSSELL EARL, Jun., resigned Dec. 29, 1933.

THOMAS, WESTON GAGE, Assoc. M., resigned Dec. 8, 1933.

WALDORF, WALLACE ASTOR, Assoc. M., resigned Jan. 2, 1934.

TILGHMAN, HARRISON, Assoc. M., resigned Dec. 27, 1933.

WARD, HAROLD MANDEVILLE, M., resigned Dec. 12, 1933.

WARREN, GEORGE COPP, Affiliate, resigned Dec. 12, 1933.

WATSON-MACINNES, JOHN, Jun., resigned Jan. 4, 1934.

WEISS, FREDERICK MARTIN, Jun., resigned Dec. 28, 1933.

WILLIAMS, RALPH STANLEY, Assoc. M., resigned Dec. 27, 1933.

WINSLOW, BURTON LYMAN, Assoc. M., resigned Dec. 20, 1933.

DEATHS

AMWEG, FREDERICK JAMES. Elected M., Mar. 7, 1888; died Dec. 28, 1933.

AREND, ALBERT CORNELIUS. Elected Assoc. M., Feb. 2, 1909; M., Jan. 16, 1917; died Oct. 2, 1933.

BROWNELL, JAMES PARKER. Elected M., June 24, 1914; died Dec. 17, 1933.

CLARK, DAVID. Elected Assoc. M., Sept. 12, 1921; M., July 12, 1927; date of death unknown.

CONNELLY, JOSEPH AUGUSTINE ALOYSIUS. Elected Assoc. M., Feb. 4, 1913; died Jan. 1, 1934.

FLYNN, HARRY FRANKLIN. Elected Assoc. M., Dec. 6, 1915; M., April 21, 1920; died Dec. 14, 1933.

HAYDEN, THOMAS JEFFERSON, JR. Elected Jun., Oct. 26, 1931; died Dec. 9, 1933.

HENSHAW, FRED FORBES. Elected M., Aug. 9, 1920; died Dec. 26, 1933.

IRVINE, VIVION ROSE. Elected M., May 28, 1923; died Dec. 16, 1933.

MAHONEY, ARTHUR SAWYER. Elected Assoc. M., Aug. 28, 1922; died April 18, 1933.

PENDERGRASS, ROBERT ALLEN. Elected M., June 3, 1908; Assoc. M., Oct. 31, 1911; died Dec. 20, 1933.

STILES, JOHN CHADWICK. Elected Assoc. M., Mar. 16, 1925; died Nov. 22, 1933.

THOROUGHGOOD, ROBERT WILLIAM. Elected M., Mar. 30, 1931; died Dec. 7, 1933.

TOTAL MEMBERSHIP AS OF JANUARY 9, 1934

Members	5,753
Associate Members	6,267
Corporate Members	12,020
Honorary Members	18
Juniors	3,067
Affiliates	109
Fellows	5
Total	15,219

Men Available

These items are from information furnished by the Engineering Societies Employment Service, with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fee is to be found on page 97 of the 1933 Year Book of the Society. To expedite publication, notices should be sent direct to the Employment Service, 31 West 39th Street, New York, N.Y. Employers should address replies to the key number, care of the New York Office, unless the word Chicago or San Francisco follows the key number, when the reply should be sent to the office designated.

CONSTRUCTION

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 29; B.S. in C.E., New York University; 7 years experience with general contractors and engineers; estimating, design, drafting, surveying, and layout work; in responsible charge of construction in the field. Available immediately. Location immaterial. D-2728.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; graduate C.E.; 29; married; 9 years experience with one firm of general contracting builders and engineers; all types of building construction. Experienced in estimating, construction analyses, drafting, design, office routine, supervision of construction in field, surveying, layout work. In responsible charge for several years. D-2712.

DESIGN

CIVIL AND STRUCTURAL ENGINEER; Jun. Am. Soc. C.E.; 29; B.S. in C.E. and C.E. degrees; about 5 years experience in New York City as a designer, detailer, draftsman, checker, and estimator of steel and reinforced concrete. References and samples of work sent on request. C-6186.

STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; 38; married; graduate; state licenses; 10 years experience, surveying, design, and construction. Design, detail, preparation of plans and specifications, on railroad, highway, parkway, harbor, and tall building structures. Completely familiar with the design of rigid-frame bridges. Available immediately. D-1496.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; graduate C.E.; 19 years diversified experience with nationally known organizations. Experience includes survey work, design and details of structural steel and reinforced concrete, plant layout, machinery location and details, elevators, conveyors, transmission, etc. Accurate; reliable. Available immediately. D-1028.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 45; with 25 years experience in structural and mechanical fields, including the design, checking, and detailing of structural steel for office, apartment, and mill buildings, and the design, detail, and construction of coal and ash-handling plants and equipment. Location, New York and vicinity. A-3807.

STRUCTURAL DESIGNER; Assoc. M. Am. Soc. C.E.; 31; married; licensed professional engineer and land surveyor, New York State; graduate, Rensselaer Polytechnic Institute; 10 years intensive practice; 8 years with consulting bridge engineer; design, specification, estimates, reports; movable bridges; buildings. Recently associated on design of large vertical-lift bridge. Available on short notice. D-506.

EXECUTIVE

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 41; married; graduate B.S. in C.E.; New York State licensed professional engineer; 11 years experience as surveyor, inspector, estimator, assistant engineer, superintendent on building and heavy construction; 10 years engineer and contractor (own business) on building construction, bulk gasoline plants, alterations. Location, New York City. Available immediately. B-2044.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 19 years experience in sanitary and municipal work on design and construction of sewerage systems, including treatment works, water supply systems, streets and pavements, preliminary investigations, and reports. Technical graduate. Married. Seeks connection with consulting engineering or with contracting firm. A-466.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; college graduate; 38; married; specialized in reinforced concrete construction. For the past 9 years in charge of the design, estimate, detailing, and supervision of fireproof floor systems and all types of buildings. Desires permanent connection in metropolitan New York or New Jersey. B-7608.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 37; married; graduate of Massachusetts Institute of Technology. Experienced structural steel erection—office buildings, apartment houses, bridges, viaducts, etc.; loading, unloading, and yard storage; fabricating-shop practice; field engineering; erection estimating; costs. Desires executive field or office position. Vicinity of New York preferred. Available immediately. C-2210.

EXECUTIVE; Jun. Am. Soc. C.E.; licensed professional engineer; member of New York Bar; graduate of Manhattan College and Fordham Law School; 28. Experience: Instructor in engineering at Manhattan; design and valuation, New York Central Terminal; valuation and estimating with architect; practice of law, real estate, and contractor's liens. Situation desired with executive department. C-3265.

EXECUTIVE; Assoc. M. Am. Soc. C.E.; civil engineer; 34; registered professional engineer; graduate of University of Pennsylvania; 10 years experience. Sales organization and promotion. Consultation, planning, and construction—industrial buildings. Protestant. Married. Language—Spanish. Available. C-3604.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 32; professional engineer, licensed in New York State; C.E. and B.S. degrees; 10 years varied experience in construction on New York subway work. Will consider any position connected with engineering. B-7933.

ENGINEER; M. Am. Soc. C.E.; technical education; 20 years experience; New York license; certificate, National Bureau of Engineering Registration. Design, construction, maintenance, executive, sales. Power and industrial plants, steel structures, railroad and contractors' equipment, conveying and storage plants. B-4537.

CONCRETE SPECIALIST; Jun. Am. Soc. C.E.; 32; 5 years experience on construction projects in charge of field testing laboratories for the control of concrete aggregates, proportioning mixes, and testing concrete. C-3432.

CIVIL ENGINEER; M. Am. Soc. C.E.; graduate, Delft University, Holland; 49; licensed, New York; 9 years responsible charge, construction of tunnels and bridges; 3 years railroad maintenance, trackwork, and design; 5 years as inspector of 300 railroad structures; 10 years in responsible charge of material testing and inspection for 500-million-dollar construction project. D-2255.

SANITARY ENGINEER; Assoc. M. Am. Soc. C.E.; expert on stream pollution, sewage and industrial wastes disposal; 10 years experience with largest disposal project in the United States; also sales promotion and reports on new developments with private corporation; qualified to investigate, study, report, design, operate, or take charge. D-1161.

STRUCTURAL ENGINEER EXECUTIVE; M. Am. Soc. C.E.; 46; married; extraordinary general business experience and practical efficient reorganization in steel fabricating business. Over 20 years in supervising estimating, designing, and sales, together with coordination of shop and field. Also very successful record as district representative. C-5095.

JUNIOR

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 29; married; B.S. in C.E., Carnegie Institute of Technology; high in mechanics, physics, mathematics; 7 years practical experience, reconnaissance, survey, and construction work; 5 years with U.S. Government. Will consider teaching, research, and construction work, also entering partnership with established engineer. D-2744.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 26; single; B.S. in C.E., New York University, 1929; 3½ years with the Long Island Railroad on grade-crossing eliminations. Experienced in all phases of work; surveying, estimating, railroad R. and E. accounting, specifications. Desires position in any branch of civil engineering. Salary immaterial. C-6244.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 24; single; B.C.E., Brooklyn Polytechnic Institute, 1932. Competent mathematician, draftsman; licensed land surveyor, New York; 8 years office and field experience—city, farm, title, topographic, private geodetic surveys; street and sewer locations; tenement-house and office-building construction. Desires permanent connection in any branch of civil engineering, surveying, bridge design, etc. Location immaterial. D-2661.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 27; graduate; 4 years with construction outfits, mostly contractors on river tunnel construction as assistant engineer. Chief of party on surveys, land and water; estimating, designing, drafting, inspection. Wide experience. Desires work with contractor. Location immaterial. Available on one week's notice. D-1921.

MISCELLANEOUS

EXPERT WITNESS in the fields of water supply, drainage, and sewerage; M. Am. Soc. C.E. Prepared to make a complete inventory and appraisal and to take the witness stand in a competent manner. Licensed in New York and New Jersey and qualified as an expert in Connecticut. D-704.

SALES

BUSINESS GETTER; Assoc. M. Am. Soc. C.E.; persuasive contacts with a particular class of colleges, schools, and hospitals; open for engagement by large firm having a meritorious product. Commission with drawing account. B-9276.

TEACHING

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; married; B.S. in C.E., Massachusetts Institute of Technology; candidate this year for M.S. in C.E. at Yale University; 10½ years practical experience in design and construction of bridges, buildings, and dams; 9 years teaching structural engineering, concrete and descriptive geometry at leading university. Location in East preferred. B-3516.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 25; A.B., Dartmouth College, 1929; C.E., Thayer School of Civil Engineering, 1930; M.S., Rutgers University, 1933; 1½ years as structural detailer; 4 months on construction. Desires position teaching structures or applied mechanics or working on construction job. C-9997.

RECENT BOOKS

New books of interest to Civil Engineers, donated by the publishers to the Engineering Societies Library, or to the Society's Reading Room, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on page 87 of the Year Book for 1933. These notes regarding the books are taken from the books themselves, and this Society is not responsible for them.

BEMESSUNGSBUCH FÜR EISENBETON. Anleitung, Formeln und Tabellen zum wirtschaftlichen Bemessen von Eisenbetonquerschnitten. By K. Bernhard. Munich and Berlin, R. Oldenbourg, 1933. 182 pp., diagrs., charts, tables, 12 × 8 in., cloth, 22 rm.

A comprehensive collection of tables and formulas for the designer of reinforced-concrete structures, intended to facilitate the dimensioning of members. Methods are described and illustrated by worked-out examples. The tables cover usual needs and conform to German standards.

GEOLOGY OF CALIFORNIA. By R. D. Reed. Tulsa, Okla., American Association of Petroleum Geologists, 1933. 355 pp., illus., maps, tables, 9 × 6 in., cloth, $5.

A sketch of the stratigraphy, structure, and geologic history of California, with particular reference to post-Triassic events in the coastal province; some of the major unsolved problems of California geology; and the present status of geologic work in the state.

INTERNATIONAL ACETYLENE ASSOCIATION PROCEEDINGS, 33d Annual Convention, 1932. New York, The Association, 1933. 201 pp., 9 × 6 in., cloth, not for sale.

The uses of oxy-acetylene cutting and welding processes in various industries and manufacturing processes; the use of welded piping in power plants and residences; welding in the aircraft industry and in railroad and truck maintenance; and weld testing.

INVENTIONS, PATENTS AND TRADE-MARKS, THEIR PROTECTION AND PROMOTION. 2 ed. By M. Wright. New York and London, McGraw-Hill Book Co., 1933. 310 pp., 8 × 6 in., cloth, $2.50.

An experienced attorney here discusses in a practical way many questions frequently asked by inventors. He tells how to choose a patent attorney, what patent-office procedure is, and how to estimate the value of a patent. Methods of disposing of patents are described; the relations of inventor and employer are discussed; and various traps set for patentees are noted.

MANUAL OF STRUCTURAL DESIGN. By J. Singleton, Topeka, Kans., H. M. Ives and Sons, 1933. 196 pp., diagrs., charts, tables, 10 × 7 in., leather, 4.50.

This handbook was prepared by an experienced designer, with the aim of providing, in one volume, all information required to solve ordinary problems relating both to structural steel and reinforced concrete. It is intended for the practial engineer, conversant with the theory of structural design. The tables conform to the specification of the American Concrete Institute and the American Institute of Steel Construction.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN GHH-Konzern, Band 2, Heft 9, November 1933: Die Seile für die Gipfelstrecke der bayerischen Zugspitzbahn, by R. Meebold; Untersuchungen über den Reitstockspitzendruck beim Drehen schwerer Werkstücke, by K. F. Brill; and Der Widerstand einer Schweissverbindung gegen Beanspruchung durch Schrumpfen, by R. Hochheim. Berlin, VDI-Verlag, pp. 235–262, illus., diagrs., charts, tables, 12 × 8 in., paper, 3.15 rm.

These papers from the research laboratories of various German factories discuss the construction and testing of the cable for a large passenger cableway, the pressure on lathe centers supporting heavy pieces, and the resistance to contraction of welds.

ROHRHYDRAULIK, ALLGEMEINE GRUNDLAGEN, FORSCHUNG, PRAKTISCHE BERECHNUNG UND AUSFÜHRUNG VON ROHRLEITUNGEN. By H. Richter. Berlin, Julius Springer, 1934. 256 pp., diagrs., charts, tables, 10 × 6 in., cloth, 22.50 rm.

A practical summary of all available useful information upon the flow of fluids in pipes. The first section is devoted to the physical principles of flow and includes an extensive collection of numerical data upon the viscosities of industrial fluids and mixtures. The second discusses theoretical considerations and the data upon the flow of liquids and gases in pipes obtained through the research work of recent years. The third section treats of the practical design and construction of pipe lines for liquids and gases. A collection of useful formulas for various conditions of flow, with examples of their use.

STEEL FRAMING FOR SMALL RESIDENCES. Published by Subsidiary Companies of the United States Steel Corporation, New York, N.Y., 1933. 54 pp., illus., diagrs., tables, 11 × 8½ in., paper, 50 cents.

The outcome of a detailed survey recently made by a trade research committee drawn from subsidiary companies of the United States Steel Corporation for the purpose of investigating the potential demand for steel in residence construction. Nearly one hundred different systems of construction were studied for the purpose of providing architects, builders, and fabricators with available information on the safe, practical, and economic use of steel in the framework of small residences. New practices are explained, and their application exemplified.

THÉORIE GÉNÉRALE DU COUP DE BÉLIER. By C. Jaeger. Paris, Dunod, 1933. 268 pp., diagrs., charts, tables, 10 × 7 in., paper, 86 frs.

Allievi's theory of water hammer, which is usually applied to the solution of water-hammer problems, is rigorously applicable only to conduits of uniform diameter and elasticity. The present work extends Allievi's theory to a general form by means of which the pressure can be calculated at any point of a conduit in which the sections and elasticity vary and which empties into a surge tank of any type, under any conditions of gate closure.

WORLD RESOURCES AND INDUSTRIES. By E. W. Zimmermann. New York and London, Harper Brothers, 1933. 842 pp., illus., diagrs., charts, maps, tables, 10 × 6 in., cloth, $5.

A timely appraisal of world resources in the light of a dynamic, rather than a static, concept. The agricultural and industrial resources of the world are reviewed, stress being laid upon their relativity and functional nature. Future prospects are discussed. The book has much of interest to economists, manufacturers, and business men.